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The United States Air Force Summer Research Program (USAF-SRP) is designed to introduce university, college, and technical institute faculty members, graduate students, and high school students to Air Force research. This is accomplished by the faculty members (Summer Faculty Research Program, (SFRP)), graduate students (Graduate Student Research Program (GSRP)), and high school students (High School Apprenticeship Program (HSAP)) being selected on a nationally advertised competitive basis during the summer intersession period to perform research at Air Force Research Laboratory (AFRL) Technical Directorates, Air Force Air Logistics Centers (ALC), and other AF Laboratories. This volume consists of a program overview, program management statistics, and the final technical reports from the HSAP participants at the Wright Laboratory.

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UNITED STATES AIR FORCE

SUMMER RESEARCH PROGRAM -- 1998

HIGH SCHOOL APPRENTICESHIP PROGRAM FINAL REPORTS

VOLUME 15A

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Washington, D.C.

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PREFACE

Reports in this volume are numbered consecutively beginning with number 1. Each report is paginated with the report number followed by consecutive page numbers, e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

Due to its length, Volume 15 is bound in three parts, 5A, 5B and 5C. Volume 5A contains #1-18. Volume 5B contains reports #19-36, and Volume 5B contains reports #37-59. The Table of Contents for Volume 5 is included in all parts.

This document is one of a set of 15 volumes describing the 1998 AFOSR Summer Research Program. The following volumes comprise the set:

VOLUME	TITLE
1	Program Management Report
	Summer Faculty Research Program (SFRP) Reports
2	Armstrong Laboratory
3	Phillips Laboratory
4	Rome Laboratory
5A & 5B	Wright Laboratory
6	Arnold Engineering Development Center, United States Air Force Academy and Air Logistics Centers
	Graduate Student Research Program (GSRP) Reports
7	Armstrong Laboratory
8	Phillips Laboratory
9	Rome Laboratory
10	Wright Laboratory
11	Arnold Engineering Development Center and Wilford Hall Medical Center
	High School Apprenticeship Program (HSAP) Reports
12	Armstrong Laboratory
13	Phillips Laboratory
14	Rome Laboratory
15A, 15B & 15C	Wright Laboratory

HSAP FINAL REPORTS

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1. INTRODUCTION

The Summer Research Program (SRP), sponsored by the Air Force Office of Scientific Research (AFOSR), offers paid opportunities for university faculty, graduate students, and high school students to conduct research in U.S. Air Force research laboratories nationwide during the summer.

Introduced by AFOSR in 1978, this innovative program is based on the concept of teaming academic researchers with Air Force scientists in the same disciplines using laboratory facilities and equipment not often available at associates' institutions.

The Summer Faculty Research Program (SFRP) is open annually to approximately 150 faculty members with at least two years of teaching and/or research experience in accredited U.S. colleges, universities, or technical institutions. SFRP associates must be either U.S. citizens or permanent residents.

The Graduate Student Research Program (GSRP) is open annually to approximately 100 graduate students holding a bachelor's or a master's degree; GSRP associates must be U.S. citizens enrolled full time at an accredited institution.

The High School Apprentice Program (HSAP) annually selects about 125 high school students located within a twenty mile commuting distance of participating Air Force laboratories.

AFOSR also offers its research associates an opportunity, under the Summer Research Extension Program (SREP), to continue their AFOSR-sponsored research at their home institutions through the award of research grants. In 1994 the maximum amount of each grant was increased from $20,000 to $25,000, and the number of AFOSR-sponsored grants decreased from 75 to 60. A separate annual report is compiled on the SREP.

The numbers of projected summer research participants in each of the three categories and SREP "grants" are usually increased through direct sponsorship by participating laboratories.

AFOSR's SRP has well served its objectives of building critical links between Air Force research laboratories and the academic community, opening avenues of communications and forging new research relationships between Air Force and academic technical experts in areas of national interest, and strengthening the nation's efforts to sustain careers in science and engineering. The success of the SRP can be gauged from its growth from inception (see Table 1) and from the favorable responses the 1997 participants expressed in end-of-tour SRP evaluations (Appendix B).

AFOSR contracts for administration of the SRP by civilian contractors. The contract was first awarded to Research & Development Laboratories (RDL) in September 1990. After completion of the 1990 contract, RDL (in 1993) won the recompetition for the basic year and four 1-year options.

2. PARTICIPATION IN THE SUMMER RESEARCH PROGRAM

The SRP began with faculty associates in 1979; graduate students were added in 1982 and high school students in 1986. The following table shows the number of associates in the program each year.

YEAR	SRP Participation, by Year			TOTAL
	SFRP	GSRP	HSAP	
1979	70			70
1980	87			87
1981	87			87
1982	91	17		108
1983	101	53		154
1984	152	84		236
1985	154	92		246
1986	158	100	42	300
1987	159	101	73	333
1988	153	107	101	361
1989	168	102	103	373
1990	165	121	132	418
1991	170	142	132	444
1992	185	121	159	464
1993	187	117	136	440
1994	192	117	133	442
1995	190	115	137	442
1996	188	109	138	435
1997	148	98	140	427
1998	85	40	88	213

Beginning in 1993, due to budget cuts, some of the laboratories weren't able to afford to fund as many associates as in previous years. Since then, the number of funded positions has remained fairly constant at a slightly lower level.

3. RECRUITING AND SELECTION

The SRP is conducted on a nationally advertised and competitive-selection basis. The advertising for faculty and graduate students consisted primarily of the mailing of 8,000 52-page SRP brochures to chairpersons of departments relevant to AFOSR research and to administrators of grants in accredited universities, colleges, and technical institutions. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) were included. Brochures also went to all participating USAF laboratories, the previous year's participants, and numerous individual requesters (over 1000 annually).

RDL placed advertisements in the following publications: *Black Issues in Higher Education, Winds of Change,* and *IEEE Spectrum.* Because no participants list either *Physics Today* or *Chemical & Engineering News* as being their source of learning about the program for the past several years, advertisements in these magazines were dropped, and the funds were used to cover increases in brochure printing costs.

High school applicants can participate only in laboratories located no more than 20 miles from their residence. Tailored brochures on the HSAP were sent to the head counselors of 180 high schools in the vicinity of participating laboratories, with instructions for publicizing the program in their schools. High school students selected to serve at Wright Laboratory's Armament Directorate (Eglin Air Force Base, Florida) serve eleven weeks as opposed to the eight weeks normally worked by high school students at all other participating laboratories.

Each SFRP or GSRP applicant is given a first, second, and third choice of laboratory. High school students who have more than one laboratory or directorate near their homes are also given first, second, and third choices.

Laboratories make their selections and prioritize their nominees. AFOSR then determines the number to be funded at each laboratory and approves laboratories' selections.

Subsequently, laboratories use their own funds to sponsor additional candidates. Some selectees do not accept the appointment. so alternate candidates are chosen. This multi-step selection procedure results in some candidates being notified of their acceptance after scheduled deadlines. The total applicants and participants for 1998 are shown in this table.

1998 Applicants and Participants			
PARTICIPANT CATEGORY	TOTAL APPLICANTS	SELECTEES	DECLINING SELECTEES
SFRP	382	85	13
(HBCU/MI)	(0)	(0)	(0)
GSRP	130	40	7
(HBCU/MI)	(0)	(0)	(0)
HSAP	328	88	22
TOTAL	840	213	42

4. SITE VISITS

During June and July of 1998, representatives of both AFOSR/NI and RDL visited each participating laboratory to provide briefings, answer questions, and resolve problems for both laboratory personnel and participants. The objective was to ensure that the SRP would be as constructive as possible for all participants. Both SRP participants and RDL representatives found these visits beneficial. At many of the laboratories, this was the only opportunity for all participants to meet at one time to share their experiences and exchange ideas.

5. HISTORICALLY BLACK COLLEGES AND UNIVERSITIES AND MINORITY INSTITUTIONS (HBCU/MIs)

Before 1993, an RDL program representative visited from seven to ten different HBCU/MIs annually to promote interest in the SRP among the faculty and graduate students. These efforts were marginally effective, yielding a doubling of HBCI/MI applicants. In an effort to achieve AFOSR's goal of 10% of all applicants and selectees being HBCU/MI qualified, the RDL team decided to try other avenues of approach to increase the number of qualified applicants. Through the combined efforts of the AFOSR Program Office at Bolling AFB and RDL, two very active minority groups were found, HACU (Hispanic American Colleges and Universities) and AISES (American Indian Science and Engineering Society). RDL is in communication with representatives of each of these organizations on a monthly basis to keep up with the their activities and special events. Both organizations have widely-distributed magazines/quarterlies in which RDL placed ads.

Since 1994 the number of both SFRP and GSRP HBCU/MI applicants and participants has increased ten-fold, from about two dozen SFRP applicants and a half dozen selectees to over 100 applicants and two dozen selectees, and a half-dozen GSRP applicants and two or three selectees to 18 applicants and 7 or 8 selectees. Since 1993, the SFRP had a two-fold applicant increase and a two-fold selectee increase. Since 1993, the GSRP had a three-fold applicant increase and a three to four-fold increase in selectees.

In addition to RDL's special recruiting efforts, AFOSR attempts each year to obtain additional funding or use leftover funding from cancellations the past year to fund HBCU/MI associates.

SRP HBCU/MI Participation, By Year				
YEAR	SFRP		GSRP	
	Applicants	Participants	Applicants	Participants
1985	76	23	15	11
1986	70	18	20	10
1987	82	32	32	10
1988	53	17	23	14
1989	39	15	13	4
1990	43	14	17	3
1991	42	13	8	5
1992	70	13	9	5
1993	60	13	6	2
1994	90	16	11	6
1995	90	21	20	8
1996	119	27	18	7

6. SRP FUNDING SOURCES

Funding sources for the 1998 SRP were the AFOSR-provided slots for the basic contract and laboratory funds. Funding sources by category for the 1998 SRP selected participants are shown here.

1998 SRP FUNDING CATEGORY	SFRP	GSRP	HSAP
AFOSR Basic Allocation Funds	67	38	75
USAF Laboratory Funds	17	2	13
Slots Added by AFOSR (Leftover Funds)	0	0	0
HBCU/MI By AFOSR (Using Procured Addn'l Funds)	0	0	N/A
TOTAL	84	40	88

7. COMPENSATION FOR PARTICIPANTS

Compensation for SRP participants, per five-day work week, is shown in this table.

1998 SRP Associate Compensation

PARTICIPANT CATEGORY	1991	1992	1993	1994	1995	1996	1997	1998
Faculty Members	$690	$718	$740	$740	$740	$770	$770	$793
Graduate Student (Master's Degree)	$425	$442	$455	$455	$455	$470	$470	$484
Graduate Student (Bachelor's Degree)	$365	$380	$391	$391	$391	$400	$400	$412
High School Student (First Year)	$200	$200	$200	$200	$200	$200	$200	$200
High School Student (Subsequent Years)	$240	$240	$240	$240	$240	$240	$240	$240

The program also offered associates whose homes were more than 50 miles from the laboratory an expense allowance (seven days per week) of $52/day for faculty and $41/day for graduate students. Transportation to the laboratory at the beginning of their tour and back to their home destinations at the end was also reimbursed for these participants. Of the combined SFRP and GSRP associates, 65 % claimed travel reimbursements at an average round-trip cost of $730.

Faculty members were encouraged to visit their laboratories before their summer tour began. All costs of these orientation visits were reimbursed. Forty-three percent (85 out of 188) of faculty associates took orientation trips at an average cost of $449. By contrast, in 1993, 58 % of SFRP associates elected to take an orientation visits at an average cost of $685; that was the highest percentage of

associates opting to take an orientation trip since RDL has administered the SRP, and the highest average cost of an orientation trip.

Program participants submitted biweekly vouchers countersigned by their laboratory research focal point, and RDL issued paychecks so as to arrive in associates' hands two weeks later.

This is the third year of using direct deposit for the SFRP and GSRP associates. The process went much more smoothly with respect to obtaining required information from the associates, about 15% of the associates' information needed clarification in order for direct deposit to properly function as opposed to 7% from last year. The remaining associates received their stipend and expense payments via checks sent in the US mail.

HSAP program participants were considered actual RDL employees, and their respective state and federal income tax and Social Security were withheld from their paychecks. By the nature of their independent research, SFRP and GSRP program participants were considered to be consultants or independent contractors. As such, SFRP and GSRP associates were responsible for their own income taxes, Social Security, and insurance.

8. CONTENTS OF THE 1998 REPORT

The complete set of reports for the 1998 SRP includes this program management report (Volume 1) augmented by fifteen volumes of final research reports by the 1998 associates, as indicated below:

1998 SRP Final Report Volume Assignments

LABORATORY	SFRP	GSRP	HSAP
Armstrong	2	7	12
Phillips	3	8	13
Rome	4	9	14
Wright	5A, 5B	10	15
AEDC, ALCs, USAFA, WHMC	6	11	

APPENDIX A – PROGRAM STATISTICAL SUMMARY

A. Colleges/Universities Represented

Selected SFRP associates represented 169 different colleges, universities, and institutions, GSRP associates represented 95 different colleges, universities, and institutions.

B. States Represented

SFRP -Applicants came from 47 states plus Washington D.C. Selectees represent 44 states.

GSRP - Applicants came from 44 states. Selectees represent 32 states.

HSAP - Applicants came from thirteen states. Selectees represent nine states.

Total Number of Participants	
SFRP	85
GSRP	40
HSAP	88
TOTAL	213

Degrees Represented			
	SFRP	GSRP	TOTAL
Doctoral	83	0	83
Master's	1	3	4
Bachelor's	0	22	22
TOTAL	186	25	109

SFRP Academic Titles	
Assistant Professor	36
Associate Professor	34
Professor	15
Instructor	0
Chairman	0
Visiting Professor	0
Visiting Assoc. Prof.	0
Research Associate	0
TOTAL	85

Source of Learning About the SRP		
Category	Applicants	Selectees
Applied/participated in prior years	177	47
Colleague familiar with SRP	104	24
Brochure mailed to institution	101	21
Contact with Air Force laboratory	101	39
IEEE Spectrum	12	1
BIIHE	4	0
Other source	117	30
TOTAL	616	162

APPENDIX B – SRP EVALUATION RESPONSES

1. OVERVIEW

Evaluations were completed and returned to RDL by four groups at the completion of the SRP. The number of respondents in each group is shown below.

Table B-1. Total SRP Evaluations Received

Evaluation Group	Responses
SFRP & GSRPs	100
HSAPs	75
USAF Laboratory Focal Points	84
USAF Laboratory HSAP Mentors	6

All groups indicate unanimous enthusiasm for the SRP experience.

The summarized recommendations for program improvement from both associates and laboratory personnel are listed below:

A. Better preparation on the labs' part prior to associates' arrival (i.e., office space, computer assets, clearly defined scope of work).

B. Faculty Associates suggest higher stipends for SFRP associates.

C. Both HSAP Air Force laboratory mentors and associates would like the summer tour extended from the current 8 weeks to either 10 or 11 weeks; the groups state it takes 4-6 weeks just to get high school students up-to-speed on what's going on at laboratory. (Note: this same argument was used to raise the faculty and graduate student participation time a few years ago.)

2. 1998 USAF LABORATORY FOCAL POINT (LFP) EVALUATION RESPONSES

The summarized results listed below are from the 84 LFP evaluations received.

1. LFP evaluations received and associate preferences:

Table B-2. Air Force LFP Evaluation Responses (By Type)

		How Many Associates Would You Prefer To Get ? (% Response)											
		SFRP				GSRP (w/Univ Professor)				GSRP (w/o Univ Professor)			
Lab	Evals Recv'd	0	1	2	3+	0	1	2	3+	0	1	2	3+
AEDC	0	-	-	-	-	-	-	-	-	-	-	-	-
WHMC	0	-	-	-	-	-	-	-	-	-	-	-	-
AL	7	28	28	28	14	54	14	28	0	86	0	14	0
USAFA	1	0	100	0	0	100	0	0	0	0	100	0	0
PL	25	40	40	16	4	88	12	0	0	84	12	4	0
RL	5	60	40	0	0	80	10	0	0	100	0	0	0
WL	46	30	43	20	6	78	17	4	0	93	4	2	0
Total	**84**	**32%**	**50%**	**13%**	**5%**	**80%**	**11%**	**6%**	**0%**	**73%**	**23%**	**4%**	**0%**

LFP Evaluation Summary. The summarized responses, by laboratory, are listed on the following page. LFPs were asked to rate the following questions on a scale from 1 (below average) to 5 (above average).

2. LFPs involved in SRP associate application evaluation process:
   a. Time available for evaluation of applications:
   b. Adequacy of applications for selection process:
3. Value of orientation trips:
4. Length of research tour:
5. a. Benefits of associate's work to laboratory:
   b. Benefits of associate's work to Air Force:
6. a. Enhancement of research qualifications for LFP and staff:
   b. Enhancement of research qualifications for SFRP associate:
   c. Enhancement of research qualifications for GSRP associate:
7. a. Enhancement of knowledge for LFP and staff:
   b. Enhancement of knowledge for SFRP associate:
   c. Enhancement of knowledge for GSRP associate:
8. Value of Air Force and university links:
9. Potential for future collaboration:
10. a. Your working relationship with SFRP:
    b. Your working relationship with GSRP:
11. Expenditure of your time worthwhile:

(Continued on next page)

12. Quality of program literature for associate:
13. a. Quality of RDL's communications with you:
    b. Quality of RDL's communications with associates:
14. Overall assessment of SRP:

Table B-3. Laboratory Focal Point Reponses to above questions

	AEDC	*AL*	*USAFA*	*PL*	*RL*	*WHMC*	*WL*
# Evals Recv'd	0	7	1	14	5	0	46
Question #							
2	-	86 %	0 %	88 %	80 %	-	85 %
2a	-	4.3	n/a	3.8	4.0	-	3.6
2b	-	4.0	n/a	3.9	4.5	-	4.1
3	-	4.5	n/a	4.3	4.3	-	3.7
4	-	4.1	4.0	4.1	4.2	-	3.9
5a	-	4.3	5.0	4.3	4.6	-	4.4
5b	-	4.5	n/a	4.2	4.6	-	4.3
6a	-	4.5	5.0	4.0	4.4	-	4.3
6b	-	4.3	n/a	4.1	5.0	-	4.4
6c	-	3.7	5.0	3.5	5.0	-	4.3
7a	-	4.7	5.0	4.0	4.4	-	4.3
7b	-	4.3	n/a	4.2	5.0	-	4.4
7c	-	4.0	5.0	3.9	5.0	-	4.3
8	-	4.6	4.0	4.5	4.6	-	4.3
9	-	4.9	5.0	4.4	4.8	-	4.2
10a	-	5.0	n/a	4.6	4.6	-	4.6
10b	-	4.7	5.0	3.9	5.0	-	4.4
11	-	4.6	5.0	4.4	4.8	-	4.4
12	-	4.0	4.0	4.0	4.2	-	3.8
13a	-	3.2	4.0	3.5	3.8	-	3.4
13b	-	3.4	4.0	3.6	4.5	-	3.6
14	-	4.4	5.0	4.4	4.8	-	4.4

3. 1998 SFRP & GSRP EVALUATION RESPONSES

The summarized results listed below are from the 120 SFRP/GSRP evaluations received.

Associates were asked to rate the following questions on a scale from 1 (below average) to 5 (above average) - by Air Force base results and over-all results of the 1998 evaluations are listed after the questions.

1. The match between the laboratories research and your field:
2. Your working relationship with your LFP:
3. Enhancement of your academic qualifications:
4. Enhancement of your research qualifications:
5. Lab readiness for you: LFP, task, plan:
6. Lab readiness for you: equipment, supplies, facilities:
7. Lab resources:
8. Lab research and administrative support:
9. Adequacy of brochure and associate handbook:
10. RDL communications with you:
11. Overall payment procedures:
12. Overall assessment of the SRP:
13. a. Would you apply again?
    b. Will you continue this or related research?
14. Was length of your tour satisfactory?
15. Percentage of associates who experienced difficulties in finding housing:
16. Where did you stay during your SRP tour?
    a. At Home:
    b. With Friend:
    c. On Local Economy:
    d. Base Quarters:
17. Value of orientation visit:
    a. Essential:
    b. Convenient:
    c. Not Worth Cost:
    d. Not Used:

SFRP and GSRP associate's responses are listed in tabular format on the following page.

Table B-4. 1997 SFRP & GSRP Associate Responses to SRP Evaluation

	Arnold	Brooks	Edwards	Eglin	Griffis	Hanscom	Kelly	Kirtland	Lackland	Robins	Tyndall	WPAFB	average
# res	6	48	6	14	31	19	3	32	1	2	10	85	257
1	4.8	4.4	4.6	4.7	4.4	4.9	4.6	4.6	5.0	5.0	4.0	4.7	4.6
2	5.0	4.6	4.1	4.9	4.7	4.7	5.0	4.7	5.0	5.0	4.6	4.8	4.7
3	4.5	4.4	4.0	4.6	4.3	4.2	4.3	4.4	5.0	5.0	4.5	4.3	4.4
4	4.3	4.5	3.8	4.6	4.4	4.4	4.3	4.6	5.0	4.0	4.4	4.5	4.5
5	4.5	4.3	3.3	4.8	4.4	4.5	4.3	4.2	5.0	5.0	3.9	4.4	4.4
6	4.3	4.3	3.7	4.7	4.4	4.5	4.0	3.8	5.0	5.0	3.8	4.2	4.2
7	4.5	4.4	4.2	4.8	4.5	4.3	4.3	4.1	5.0	5.0	4.3	4.3	4.4
8	4.5	4.6	3.0	4.9	4.4	4.3	4.3	4.5	5.0	5.0	4.7	4.5	4.5
9	4.7	4.5	4.7	4.5	4.3	4.5	4.7	4.3	5.0	5.0	4.1	4.5	4.5
10	4.2	4.4	4.7	4.4	4.1	4.1	4.0	4.2	5.0	4.5	3.6	4.4	4.3
11	3.8	4.1	4.5	4.0	3.9	4.1	4.0	4.0	3.0	4.0	3.7	4.0	4.0
12	5.7	4.7	4.3	4.9	4.5	4.9	4.7	4.6	5.0	4.5	4.6	4.5	4.6
Numbers below are percentages													
13a	83	90	83	93	87	75	100	81	100	100	100	86	87
13b	100	89	83	100	94	98	100	94	100	100	100	94	93
14	83	96	100	90	87	80	100	92	100	100	70	84	88
15	17	6	0	33	20	76	33	25	0	100	20	8	39
16a	-	26	17	9	38	23	33	4	-	-	-	30	
16b	100	33	-	40	-	8	-	-	-	-	36	2	
16c	-	41	83	40	62	69	67	96	100	100	64	68	
16d	-	-	-	-	-	-	-	-	-	-	-	0	
17a	-	33	100	17	50	14	67	39	-	50	40	31	35
17b	-	21	-	17	10	14	-	24	-	50	20	16	16
17c	-	-	-	-	10	7	-	-	-	-	-	2	3
17d	100	46	-	66	30	69	33	37	100	-	40	51	46

4. 1998 USAF LABORATORY HSAP MENTOR EVALUATION RESPONSES

Not enough evaluations received (5 total) from Mentors to do useful summary.

5. 1998 HSAP EVALUATION RESPONSES

The summarized results listed below are from the 23 HSAP evaluations received.

HSAP apprentices were asked to rate the following questions on a scale from 1 (below average) to 5 (above average)

1. Your influence on selection of topic/type of work.
2. Working relationship with mentor, other lab scientists.
3. Enhancement of your academic qualifications.
4. Technically challenging work.
5. Lab readiness for you: mentor, task, work plan, equipment.
6. Influence on your career.
7. Increased interest in math/science.
8. Lab research & administrative support.
9. Adequacy of RDL's Apprentice Handbook and administrative materials.
10. Responsiveness of RDL communications.
11. Overall payment procedures.
12. Overall assessment of SRP value to you.
13. Would you apply again next year? Yes (92 %)
14. Will you pursue future studies related to this research? Yes (68 %)
15. Was Tour length satisfactory? Yes (82 %)

	Arnold	Brooks	Edwards	Eglin	Griffiss	Hanscom	Kirtland	Tyndall	WPAFB	Totals
# resp	5	19	7	15	13	2	7	5	40	113
1	2.8	3.3	3.4	3.5	3.4	4.0	3.2	3.6	3.6	3.4
2	4.4	4.6	4.5	4.8	4.6	4.0	4.4	4.0	4.6	4.6
3	4.0	4.2	4.1	4.3	4.5	5.0	4.3	4.6	4.4	4.4
4	3.6	3.9	4.0	4.5	4.2	5.0	4.6	3.8	4.3	4.2
5	4.4	4.1	3.7	4.5	4.1	3.0	3.9	3.6	3.9	4.0
6	3.2	3.6	3.6	4.1	3.8	5.0	3.3	3.8	3.6	3.7
7	2.8	4.1	4.0	3.9	3.9	5.0	3.6	4.0	4.0	3.9
8	3.8	4.1	4.0	4.3	4.0	4.0	4.3	3.8	4.3	4.2
9	4.4	3.6	4.1	4.1	3.5	4.0	3.9	4.0	3.7	3.8
10	4.0	3.8	4.1	3.7	4.1	4.0	3.9	2.4	3.8	3.8
11	4.2	4.2	3.7	3.9	3.8	3.0	3.7	2.6	3.7	3.8
12	4.0	4.5	4.9	4.6	4.6	5.0	4.6	4.2	4.3	4.5
Numbers below are percentages										
13	60%	95%	100%	100%	85%	100%	100%	100%	90%	92%
14	20%	80%	71%	80%	54%	100%	71%	80%	65%	68%
15	100%	70%	71%	100%	100%	50%	86%	60%	80%	82%

SUBJECTIVE ASSESSMENT OF DIGITAL INFRARED IMAGES

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
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And

Wright Laboratory

August 1998

SUBJECTIVE ASSESSMENT OF DIGITAL INFRARED IMAGES

Jessica Baltes
Carroll High School

Abstract

Several sequences of infrared images taken from an airborne infrared sensor were ranked in order from best to worst by five observers. They were ranked according to erratic noise content. The results were then correlated with an objective assessment of the same sequences of images. This was to observe how similar or how different the quality of a machine vision system is to a human's vision.

SUBJECTIVE ASSESSMENT OF DIGITAL INFRARED IMAGES

Jessica Baltes

Introduction

The problem is to assess the quality of digital infrared image sequences. Subjective assessment is one way to assess the quality but it is time consuming and expensive. A better approach is an objective metric using a computer to computationally assess the quality. Machine and human vision may have different requirements for quality assessment. If the goal is to assess the quality to determine suitability for human vision consumption, then it is important that the objective metric is able to assess the quality just as a human. If the goal is to assess the quality for a machine vision system, the quality assessment must meet the input requirements of the machine vision system.

Methodology

The digital infrared images are taken from an airborne infrared (IR) sensor as it approaches ground target vehicles. The flights start with the targets out of visibility range. Typically, the flights acquire the targets as specks. As the flights gradually approach the targets, the targets increase in size until the airborne platform is just overhead. The image frames acquired by a particular flight are numbered sequentially starting with 1 and ending somewhere between 4000 and 7000 frames. For the experiments conducted in this report, the frames of interest were taken from the end of the flights since the targets were more visible. Different image sequences are obtained during different flights. An image sequence of 49 images, a sequence of 21 images, and 9 sequences of 20 images are used in both subjective and objective assessments. The images contain anywhere from one to three vehicles. The size of the image is 316 by 491 pixels. The images are quantized to 256 gray levels. Each image frame contains vehicles, dirt roads, and fairly flat terrain.

The images are shown on a Sun Microsystems monitor model GDM 20E20. The diagonal length of the screen is 18 1/8 inches. The images can be seen small or enlarged since the image window is resizable. A small image has dimensions horizontally of 4 5/8 inches and vertically of 2 7/8 inches, and a large image has dimensions horizontally of 10 3/4 inches and vertically of 6 5/8 inches. A second monitor model GDM 1962B is also used, but the measurements are consistent. The small image, though, measures 5 1/4 inches horizontally and 3 1/8 inches vertically, making it slightly larger than the small image shown on the main monitor used.

The images in each sequence are ranked in order from best to worst based on erratic noise content. The observers consist of three males and two females, all ranging in age from 15 to 18 years. Each observer ranking the images reports having 20/20 or corrected eyesight, is allowed to adjust the contrast, is not set a certain distance from the screen, and is allowed to look at each image as long as they desire, or to look at an image again in order to compare it to a later and possibly similar image. Each observer is told to look for black or possibly white dots or black lines going left to right or up and down on the screen. They are also told not to attempt to count the dots, just to make a judgment based only on what they see.

MATLAB code was used to display the images. The main display code used is titled ``subjeval", and it was modified 10 times to accommodate the different groups of images shown. Subjeval is designed to go to a directory where the images are stored, to open the file which holds the images to be displayed, and to display the first image. Then the program pauses until a key is pressed which signals the program to open the next file and to display the next image.

Each image is automatically assigned a figure number starting at 1, and each image also keeps its original frame number assigned by the flight. Since the clips were taken from the end of the flights, the frame number assigned by the flights is typically in the thousands. The observer records on paper the figure numbers in order from best to worst quality. Then, a ranking is assigned to each figure number. A rank

order variable array is created which is ordered by figure number. Then the figure numbers show where each image ranks from best to worst quality. These numbers are then put into another algorithm titled ``subjgraph", which makes it possible to print out graphs of each observer's ranking and to compare visually the results. The same set of numbers is used in an objective correlation of the results. Another display code titled ``movie1" plays the images in sequential order, making it easier to see that the erratic noise is more prominent in some image sequences than in others.

The observers are asked, after they finish ranking the images, for a description of how they rank them. They said that they looked at the images and estimated where it would be placed, and then they narrowed it down by comparing to the ones around it. One of the observers put it well: "First, I ordered about ten just by viewing them and comparing them with the others. In this process, I familiarized myself with those ten. After this, I was able to view a new image and immediately find the general area it belonged to. After I placed it in the general area, I viewed those around it and placed it in its unique spot. Through practice, I gained experience with the images and was able to locate its specific spot more efficiently." All of the other observers said that they ranked the images in similar ways. For the image sequence of 49, one observer used the same method but improvised on it. She split the sequence up into two halves: one for the good images and one for the bad images. Then she sorted the halves as usual. For the final ranking she put both halves together. Another observer had a slightly different method: "As I went through the files, I would mark each as very good, good, OK, bad, or very bad based on distortion or blurriness. I then put the pictures in order from best to worst using the ratings I gave them."

Because of the inefficiencies and the inconsistencies of each observer's methods for sorting the quality, different sort algorithms are used to see if they are more consistent and/or efficient. After the observers use their own methods for ranking the image sequences, three specific methods of sorting were chosen. These three methods were the bubble sort, the binary insertion sort, and the heap sort. The algorithms are chosen based on being the simplest and having the least number of comparisons. Bubble sort is chosen

because it is a simple, common algorithm. The drawback is that it is very inefficient. Binary insertion is chosen because it is more efficient than bubble sort and straight insertion. Heap sort is chosen because it is efficient for sorting larger amounts of data. The image sequences that were chosen to be ranked by these methods were a sequence of 20 from flight 25, and a sequence of 20 from flight 13. Two more sequences were ranked by the bubble sort method alone.

The bubble sort technique causes the best images to ``bubble" to the top while the worst images are pushed to the bottom. Images are compared in sets of two and switched if the second image being compared is better than the first image being compared. When the last two images in the set have been compared and switched if needed, then the process begins again at the beginning of the set and continues until no more changes can be made in the order of the images. At this point, the images are in order from best to worst.

The binary insertion technique involves first involves creating two piles, one for the sorted images and one for the unsorted images. All the images in the set start in the unsorted pile. After the first three images have been arranged in the sorted pile, the fourth image is compared to the second image first, since the second image is exactly in the middle of the images in the sorted pile. Each unsorted image after this is placed in the same manner, by comparing it to the middle image in the sorted pile. If the image is better, then it is compared to the image in the middle of the images above the image it was first compared to and so on.

The heap sort technique involves first creating a tree out of all the images. The images are then compared in pairs, the worse images being switched with the better images. This makes the worst images end up at the top of what is now called a heap. The image at the top of the heap can now be removed and placed at the end of the list of images from best to worst. The image in the bottom right position of what is now once again a tree in moved to the top and the process continues until all the images are removed from the tree and placed in the sorted list.

Big O notation a notation for the dominating factor in determining how many operations could be made for a given algorithm. It is proportional to the worst case time of the sort algorithms. Average number of comparisons and average time are experimental values. They show that bubble sort is the least efficient and binary insertion is the most efficient for this set of 20 images. The method of sorting does not seem to have a significant effect on the precision of the results. It does force the observer, however, to be more methodical in ranking the images.

The results from the original rankings and the sort technique results were very similar. The majority of the subjective assessment results were highly correlated with the objective results which were produced using computer algorithms. In conclusion, the machine vision algorithms were shown to register erratic noise to nearly the same degree as the human visual system and the two could be interchangeable.

GALLIUM DIFFUSION ON THE SURFACE OF GALLIUM ARSENIDE

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Final Report for:
High School Apprenticeship Program
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And

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August 1998

GALLIUM DIFFUSION ON THE SURFACE OF GALLIUM ARSENIDE

Brett R. Beckett
Waynesville High School

Abstract

Gallium diffusion on the surface of Gallium Arsenide was studied. This process is necessary for the useful production of a growth model for Molecular Beam Epitaxy. Crystal growth was studied through Molecular Beam Epitaxy at high temperatures, in near vacuum. The energy of the Beta 2x4 surface was calculated through minimization of the surface and subsequent layers of bulk Gallium Arsenide. Surface structures such as the Beta 2x4 and the C 4x4 were studied using MSI's Cerius 2 program. The electron counting rule was studied, and used to test surface stability. Using the Fortran 90 programming language, an electron counting rule program for Gallium Arsenide structures was created for use by researchers. These methods combined allowed for quick results of structures over long time scales. While not as accurate as time consuming ab-initio calculations, they do allow for reasonable results over time.

GALLIUM DIFFUSION ON THE SURFACE OF GALLIUM ARSENIDE

Brett R. Beckett

Table of Contents

Introduction

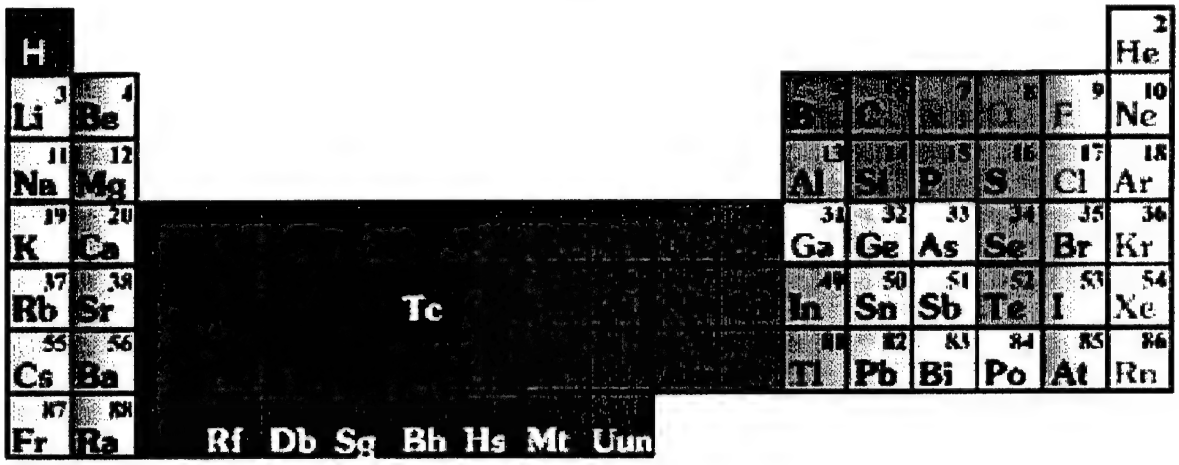
This research project began in June, 1998. It started out as a learning experience for two high school interns: Brett Beckett and Jill Seger. They learned UNIX and Fortan90 quickly, and this research project was able to begin earlier than expected.

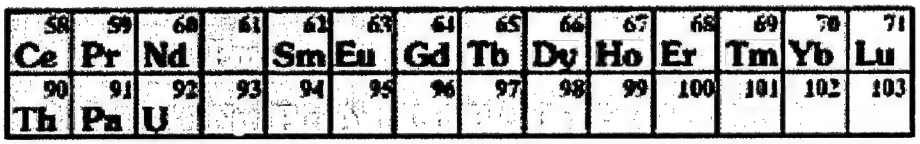
The research began as the study of Gallium Arsenide. The two students soon discovered the electron counting rule for III-V surfaces. This rule allowed to check for the stability of a Gallium Arsenide structure. They decided they needed to use this rule, and so they wrote a Fortran 90 code that will test whether or not a GaAs structure obeys the rule. The research progressed as the students then began to write a Molecular Dynamics code. While writing the code, the students learned a lot about Fortran 90 and molecular simulations.

During late July, the students mentor, Jeffrey LePage, finally managed to get the Air Force to join the Molecular Simulations Incorporated(MSI) consortium. This allowed the students to use a new tool in their research, the program Cerius 2. This program allowed them to begin running Molecular Dynamics simulations on several surfaces. It also allowed them to begin calculating the energy of several surfaces.

This research project began as a simple study of Gallium Arsenide, but in the end, it became an exciting project in the development of Gallium Arsenide studies. Within this paper, you will find a variety of different types of research, that cover a wide-range of Gallium Arsenide areas.

What is Gallium Arsenide?





Gallium Arsenide is:

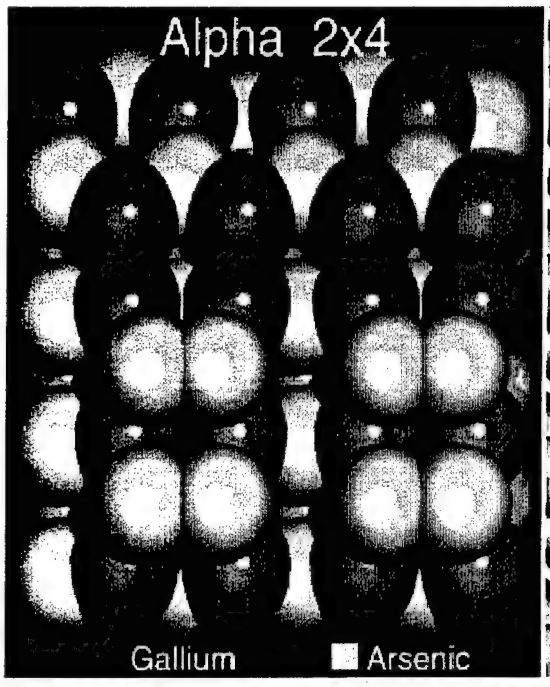
1) Gallium(31) covalently bonded to Arsenic(33)
2) A Polar compound, where the Gallium is slightly negative and the Arsenic is slightly positive
3) A direct band-gap semiconductor
4) A Structure that melts at 1238 degrees Celsius
5) Useful in many high frequency devices
6) Used in wafer forms that can be grown as large as six inches across
7) Toxic, because of the high levels of arsenic
8) A semiconductor with a resistivity greater than 10,000 ohm per centimeter

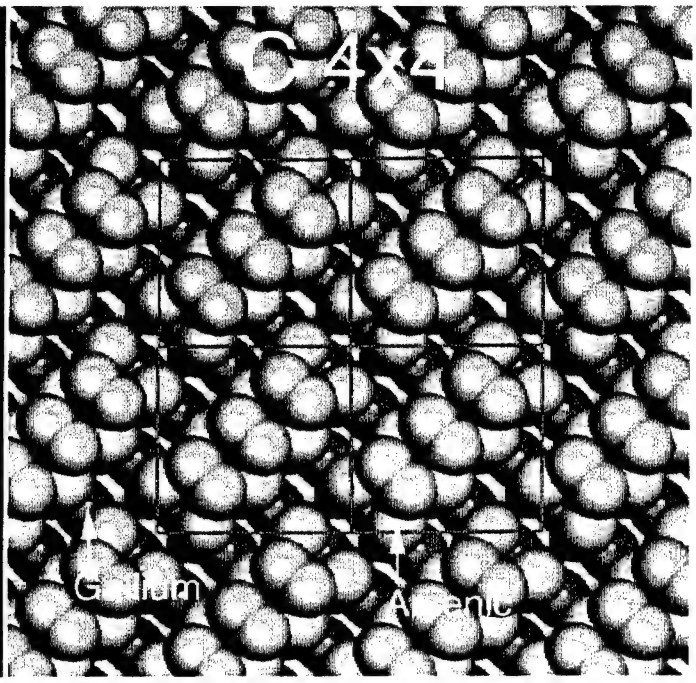
Gallium Arsenide is a semi-conductor from the III-V groups of the periodic table. Gallium(31) and Arsenic(33) are highlighted in white, in the above Periodic Table. Gallium Arsenide(GaAs) is formed covalently of equal amounts of Ga and As, except for the surfaces. Different surfaces have a variety of different ratios of Gallium to Arsenic.

Gallium Arsenide has many practical uses, and is used in many devices that you may already have. GaAs is a direct band gap semiconductor. It is used in many high frequency devices such as cell phones and satellites. Recently GaAs has been used in new solar cells that are twice as efficient as older silicon cells. It is also used for light-emitting-diodes(LEDs) and is used to generate microwaves. Gallium Arsenide integrated circuits are also used for fiber optics.

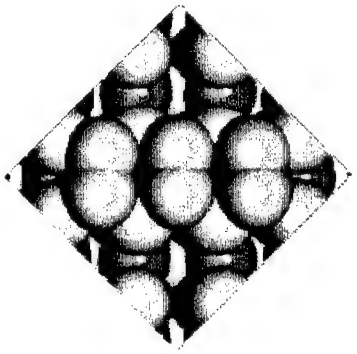
Gallium Arsenide Surfaces

There are many different Gallium Arsenide Surfaces. Two specific surfaces were used the most during this research project: the Beta 2x4 and the Beta2 2x4. Some other surfaces of interest to this group were the C 4x4, the Gamma 2x4, and the Alpha 2x4. The main difference between surfaces is dimers. A dimer is where two atoms next to each other bend together to form a bond. This stabilizes the surface, because that if they don't use the extra valence electrons in bonds, then the structure is unstable. Below are some common GaAs surfaces:

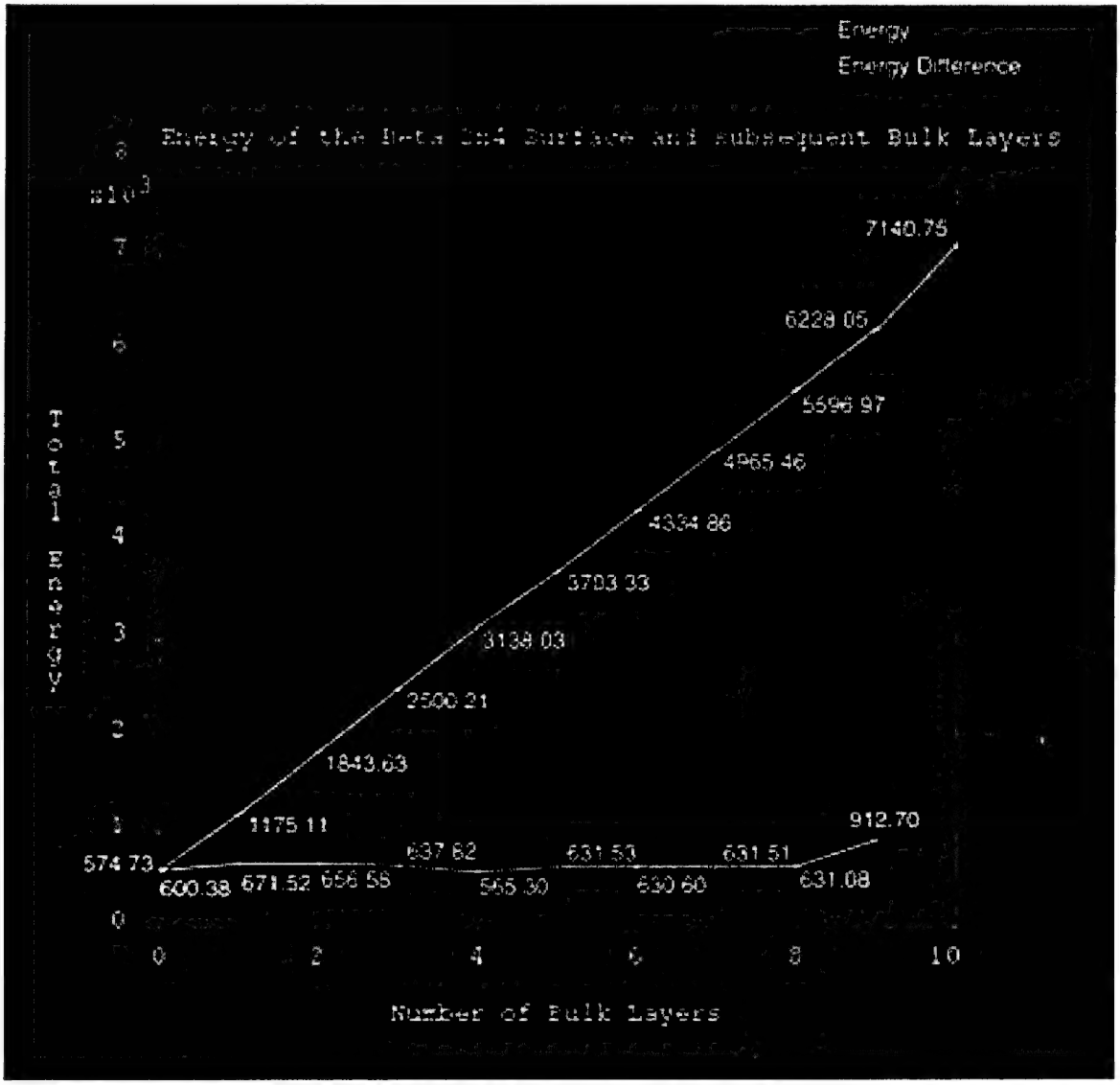




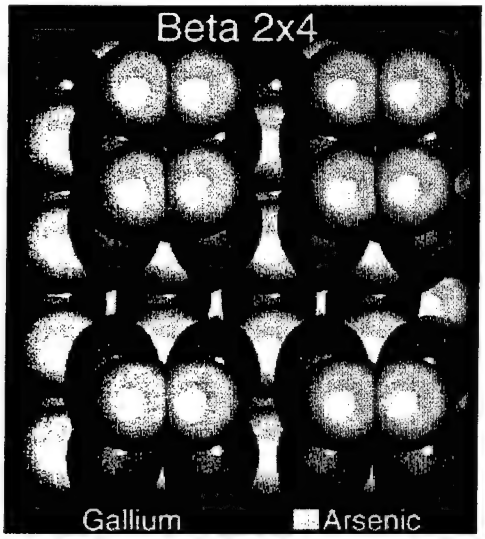
The Alpha 2x4 surface has two Arsenic dimers and two Gallium Dimers. In the above picture, the surface has been doubled to make a better picture. The C 4x4 surface is the most Arsenic rich surface. It has three Arsenc dimers attached Arsenic atoms below. The C 4x4 unit cells are "boxed" in the picture above. Usually, these cells will grow at a 45 degree angle like this:



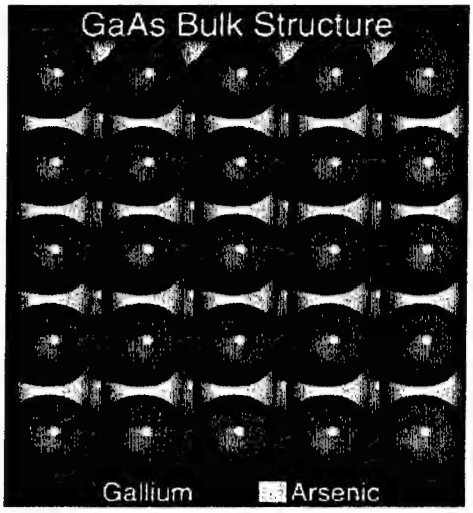
Another project was to calculate the total energy of the Beta 2x4 surface. The energy was calculated by adding successive bulk layers to the bottom of the surface, then by relaxing(or minimizing) the structure. This allowed the energy to be graphed based upon the energy of each successive bulk layer. With the energy of each bulk layer obtained, it was a simple calculation to determine the energy of the surface.



In the above graph, Energy is measured in kcal/mol. The first line is a graph of the energy of the Beta 2x4 surface with so many Bulk layers. The second line is a graph of the difference in energy between the structure(surface and bulk layers) it is on and the next structure with one more bulk layer. As you can see each bulk layer averages around 656.9 kcal/mol. Based on this information, the actual surface energy of the Beta 2x4 is around 571.73 kcal/mol.



The energy of the Beta 2x4 surface was calculated by adding subsequent layers of GaAs Bulk Structure. As you may notice, the Beta 2x4 surface used was "doubled up", so that the bulk layers would fit the surface.



The energy of the surface, the Beta 2x4, was calculated using the Drieding 2.21 forcefield/potential. This potential was used because it was the best potential available at the time of these calculations. This potential was used in conjunction with MSI's Cerius 2 program to minimize the energy.

The Electron Counting Rule

The electron counting rule is a simple, systematic way to find if a given surface reconstruction is a stable configuration. In other words, a low energy state (or at least meta-stable). It is especially useful to determine whether surfaces are or are not possible.

The electron counting rule can be used on GaAs surfaces to find possible configurations and to eliminate incorrect ones.

To apply the electron counting rule, first count the total number of electrons--5 for each As and 3 for each Ga. Then find the total number of bonds, including dangling bonds. Once you know the total number of electrons and bonds, assign two electrons to every bond, including As dangling bonds, but none to Ga dangling bonds.

For example, consider the above surface , the Beta 2x4. This structure contains the surface and one layer of bulk. On the surface, there are 14 As and 8 Ga.

The total number of electrons equals:

$$(22 * 5) + (20 * 3) = 170$$

Then count the total number of bonds, including bonds outside the unit cell, as well as dangling bonds.

71 bonds +

14 As dangling bonds +

12 Ga dangling bonds

---

99 bonds total

If we assign two atoms to each of the non-dangling bonds, we use 142 electrons. Then we assign two atoms to each As dangling bond, using 28 more electrons, and zero electrons to the Ga dangling bonds. This uses a total of 170 electrons, which is how many we have available. Therefore, the electron counting rule is obeyed, and the structure does exist.

As part of this research project, we have created a Fortran 90 source code that reads in a Gallium Arsenide surface, and checks whether or not that surface obeys the electron counting rule. The source code is available for use, and modification to your needs. The source code is located in Appendix A.

The source code is named after the man who popularized the Electron Counting Rule for III/V surfaces: M. D. Pashley.

This program/source code reads in files that are written in Xmol format. If you have never used Xmol, you may not know how to make these files so here is a simple description:

An Xmol file consists of a listing of each atom and its XYZ coordinates. The first line in the file is just the number of atoms in the structure. Then you skip a line. The following lines have the atomic symbol of the atom, then the X coord, Y coordinate, and Z coordinate. After the 3 coordinates there is an extra 0.0 for charge. There is also a part of a sample Xmol file in Appendix B.

Our program also require the size of the unit cell. This is read in through another file with the XYZ lengths of the cell. An example file with the cell lengths is also found in Appendix B.

Each of these files is named either Positions or Cell and then '.ecr'. The '.ecr' just stands for Electron counting Rule. These files are named so that they are ready to use by the program.

It is recommended that you type the source code into your computer exactly how it is in Appendix A. Then you need to compile it using a Fortran 90 compiler. The most common extension is ".f90" for Fortran 90 files, but it may need to be different for your compiler. Then to use the compiled code, create a file called "Positions.ecr". This file will include all the atoms positions in Xmol format (See Appendix B). Also create a file with the cell lengths (see Appendix B). Now place these two files in the directory with the executable. Run the program and it should tell you whether or not that surface violates the rule. If the program does not compile correctly or does not run, please check to make sure there are no typing errors in the source. If it works it will output two files. One will list all the bond angles in degrees and radians. And, the other will output all the bond lengths. For more information, see the Appendices.

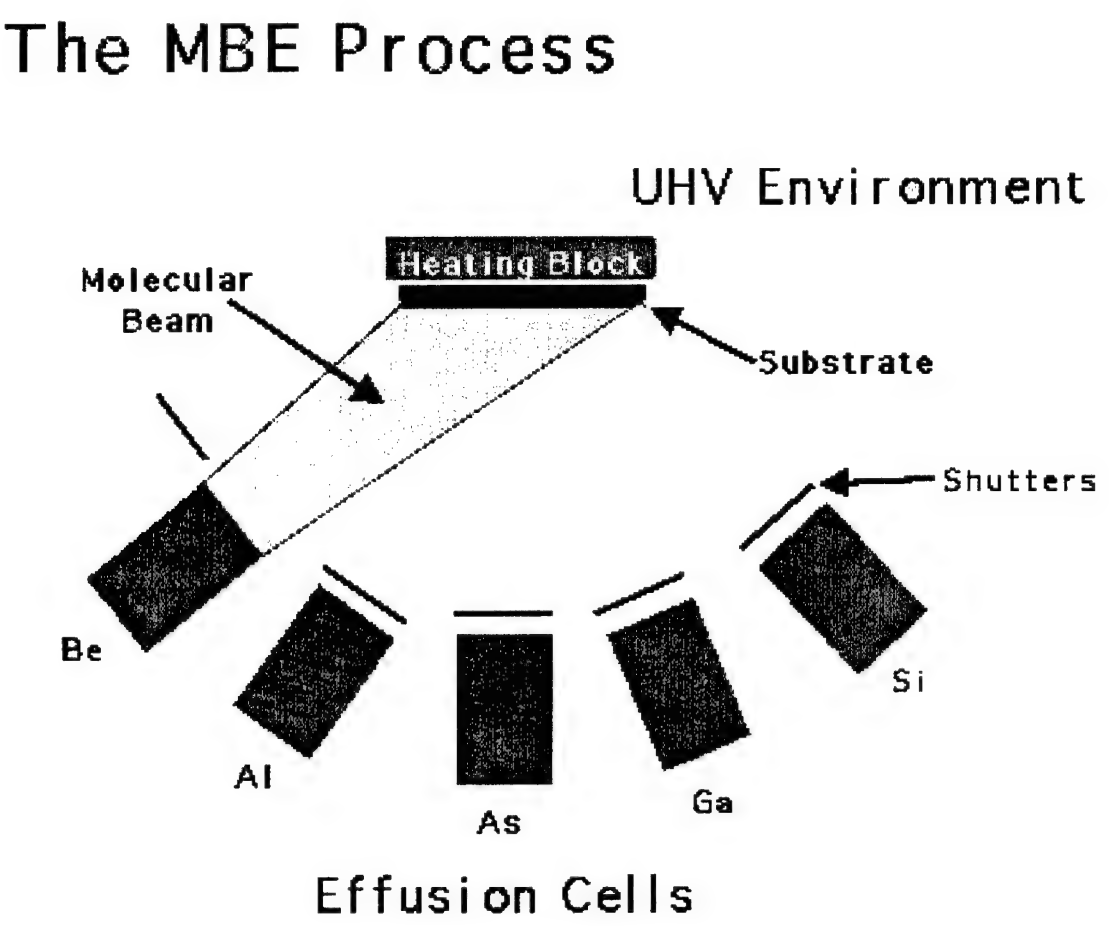
Molecular Dynamics Simulations

Throughout the Gallium Arsenide research project, there was always some form of molecular dynamics simulation involved. While calculating the energy of a surface, minimization was used. Before our research group was able to use Cerius 2, we were forced to write our own MD code for Gallium Arsenide. This code came close to being a fairly accurate MD simulator, but before it was finished we started using Cerius 2, and had no longer need for a MD source code. These simulations were used to calculate energies, simulate conditions on the surface, and to discover different forms of interactions that will occur when "extra" atoms are added to a surface. These simulations can be very helpful for use in Molecular Beam Epitaxy calculations.

Some simulations that were run are a simulation of a Gallium Dimer bonding to a Beta2 2x4 surface at 3,000 Kelvin, a Ga atom bouncing across the Beta 2x4 surface, and several minimizations. These simulations are available as an animated gifs on our website: http://www.physics.ohio-state.edu/~brettrb

Simulations were run using the Drieding 2.21 forcefield/potential.

Molecular Beam Epitaxy

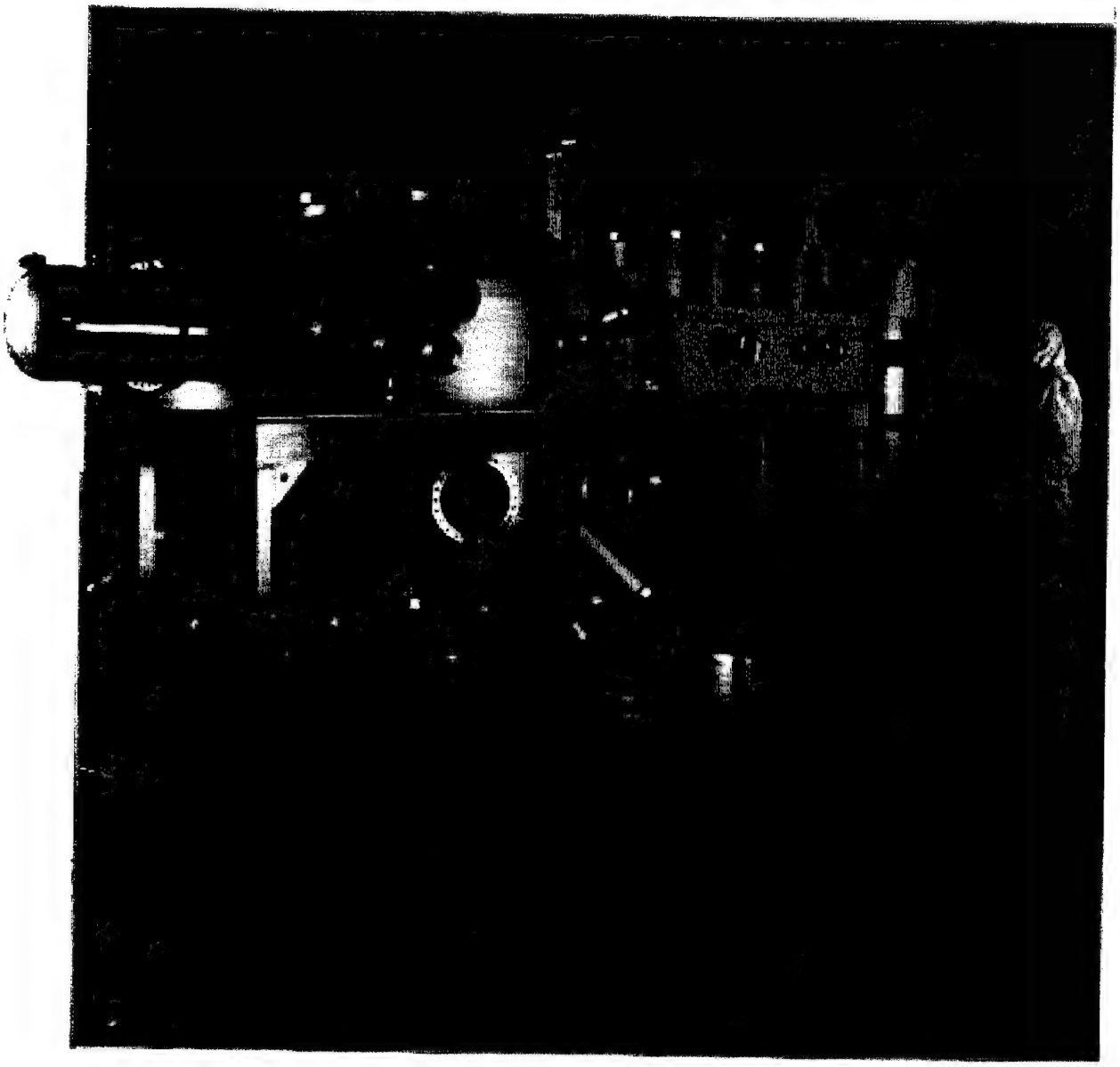


This picture of the Molecular Beam Epitaxy(MBE) process is helpful for understanding what is going on. This process occurs in almost complete vacuum, at fairly high temperatures. This process is used for growing structures on top of a substrate/material (such as Gallium Arsenide). Structures grown this way take the form of the material upon which they were grown, so unless the materials are similar the structure will form cracks, and sometimes forms quantum dots.

Effusion cells are containers of elements that are located on the sides of the MBE machine. The are closed off from the substrate by shutters. When a shutter is open, a beam of molecules comes from that container and lands on the substrate.

The MBE process allows different forms of crystals with varying properties. Usually these crystals do not have a regular "bulk" crystal, and so are needed to be grown on top of other materials. MBE allows better materials to form specialized sensors (specific band gaps) and circuits.

An actual Molecular Beam Epitaxy machine looks more like this:



Conclusions(Afterthoughts)

On technical side, I have learned a great deal concerning modern workstations, and supercomputers. Specifically, I have learned to use the UNIX OS, which is the operating system of choice for serious computing machinery. In addition, I learned to program in Fortran90, a modern scientific programming language capable of dynamic memory allocation and incorporating many features of the object oriented paradigm.

I applied this knowledge to the study of Gallium diffusion on the surface of Gallium Arsenide. Understanding how Gallium diffuses on semi-conductor surfaces is a necessary prerequisite to the formation of a growth model for Molecular Beam Epitaxy. Determining the exact nature of the bonding between the surface and the Gallium adatom requires the use of sophisticated Ab-Initio methods. However, these techniques are extremely expensive in terms of CPU hours. Therefore, we must resort to simpler methods. For instance, we have used classical molecular dynamics in conjunction with the electron counting rule to predict the stable surface reconstruction. Although these methods are not as accurate as ab-initio techniques, they are much faster and offer the researcher a means by which to investigate growth over long time scales.

Appendix A -- Electron Counting Rule Source Code(Pashley.f90)

```
!Source code created by:
!Jill Seger(jmseger@atlantic.mps.ohio-state.edu)
!Brett Beckett(brettrb@atlantic.mps.ohio-state.edu)
!http://www.physics.ohio-state.edu/~brettrb
!You may use and modify this source code as you need,
!but we ask that you leave this comment in the Source.

MODULE work

IMPLICIT NONE
REAL*8, ALLOCATABLE, SAVE :: x(:)            !position in x direction
REAL*8, ALLOCATABLE, SAVE :: y(:)            !position in y direction
REAL*8, ALLOCATABLE, SAVE :: z(:)            !position in z direction
REAL*8, ALLOCATABLE, SAVE :: vx(:)           !velocity in x direction
REAL*8, ALLOCATABLE, SAVE :: vy(:)           !velocity in y direction
REAL*8, ALLOCATABLE, SAVE :: vz(:)           !velocity in z direction
REAL*8, ALLOCATABLE, SAVE :: ax(:)           !acceleration in x direction
REAL*8, ALLOCATABLE, SAVE :: ay(:)           !acceleration in y direction
REAL*8, ALLOCATABLE, SAVE :: az(:)           !acceleration in z direction
REAL*8, ALLOCATABLE, SAVE :: fx(:)           !force in x direction
REAL*8, ALLOCATABLE, SAVE :: fy(:)           !force in y direction
REAL*8, ALLOCATABLE, SAVE :: fz(:)           !force in z direction
INTEGER, ALLOCATABLE, SAVE :: bonds(:)       !# of atoms bonded to an atom
INTEGER, SAVE :: bond_num                    !total number of bonds
CHARACTER*2, ALLOCATABLE :: species(:)       !atomic symbol
TYPE I5
  INTEGER :: vector(5)
END TYPE I5
TYPE (I5), ALLOCATABLE :: conn(:)            !connectivity of atoms; which
                                             !atoms each is connected to
INTEGER :: N                                 !number of atoms
REAL*8 :: Sx, Sy, Sz                         !Lattice constants
INTEGER :: electron_num                      !total # of electrons in system

END MODULE work

PROGRAM pashley                              !begin main program
USE work
IMPLICIT NONE

CALL start
CALL electrons
CALL find_bond_num
CALL calculate
CALL output

STOP
END PROGRAM pashley
```

```
SUBROUTINE start                        !read in positions
USE work
IMPLICIT NONE
INTEGER :: i                            !loop counter
INTEGER :: error                        !allocate term checking
INTEGER :: ioerror                        !end of file checking
REAL*8 :: Dummy2                          !variable for irrelevant info

READ(10,*) N                            !read number of atoms
REWIND 10                               !reset file
ALLOCATE(x(N), STAT = error)              !allocate arrays
IF (error /= 0) THEN
 PRINT *, 'Program could not allocate space for x.'
 STOP
OPEN (UNIT=10, FILE="Positions.ecr")
OPEN (UNIT=11, FILE="Cell.ecr")
ENDIF
ALLOCATE(y(N), STAT = error)
IF (error /=0) THEN
 PRINT *, 'Program could not allocate space for y.'
 STOP
ENDIF
ALLOCATE(z(N), STAT = error)
IF (error /=0) THEN
 PRINT *, 'Program could not allocate space for z.'
 STOP
ENDIF
ALLOCATE(species(N), STAT = error)
IF (error /= 0) THEN
 PRINT *, 'Program could not allocate space for species.'
 STOP
ENDIF
READ(10,*,IOSTAT=ioerror) N                 !read in # of atoms
IF (ioerror /= 0) THEN
 PRINT *, 'Error reading file'
ENDIF
DO i=1,N                                  !read type & position
 READ(10,*) species(i), x(i), y(i), z(i), dummy2      !of atoms
ENDDO
READ (11,*) Sx, Sy, Sz                    !read size of unit cell

END SUBROUTINE start

SUBROUTINE electrons                      !count # of total electrons
USE work
IMPLICIT NONE
INTEGER :: gallium_atoms                  !total # of Ga atoms
INTEGER :: arsenic_atoms                    !total # of As atoms
INTEGER :: i                              !loop counter

gallium_atoms = 0
arsenic_atoms = 0
```

```
DO i=1,N                                    !decide if atom is As or Ga
 IF (species(i)=='Ga') THEN
  gallium_atoms = gallium_atoms + 1
 ENDIF
 IF (species(i)=='As') THEN
  arsenic_atoms = arsenic_atoms + 1
 ENDIF
ENDDO
electron_num = arsenic_atoms * 5 + gallium_atoms * 3   !calculate # electrons

END SUBROUTINE electrons


SUBROUTINE find_bond_num                    !find number of bonds
USE work
IMPLICIT NONE
REAL*8 :: r                                 !distance between atoms
REAL*8 :: r_equi                            !equillibrium distance
REAL*8 :: xtemp, ytemp, ztemp               !temporary variables for directions
INTEGER :: i, j                             !loop counters
INTEGER :: error                            !Allocate variable

ALLOCATE (conn(N), STAT=error)              !allocate arrays
IF (error /= 0) THEN
 PRINT *, 'Program could not allocate space for conn'
 STOP
ENDIF
ALLOCATE (bonds(N), STAT=error)
IF (error /= 0) THEN
 PRINT *, 'Program could not allocate space for bonds'
 STOP
ENDIF
DO i = 1, N                                 !initiallize bonds array
 bonds(i) = 0
ENDDO
DO i = 1, N                                 !initiallize conn array
 DO j = 1, 5
  conn(i)%vector(j)=0
 ENDDO
ENDDO
r_equi = 5.6 * sqrt(3.0/16.0)                 !calculate equilibrium length
DO i = 1, N-1                               !avoiding double counting, loop
 DO j = i+1, N                              !over atoms and determine if a
                                            !bond exists
  r = sqrt( (x(i)-x(j))**2 + (y(i)-y(j))**2 + (z(i)-z(j))**2 )
                                               !caclulate
                                            !distance between atoms
  IF (r <= 1.2*r_equi) THEN                    !check if bond exists
   bond_num = bond_num + 1                     !increase total bond number
   bonds(i) = bonds(i) + 1                    !increase number of bonds on
   bonds(j) = bonds(j) + 1                    !each atom involved
   conn(i)%vector(bonds(i)) = j               !write # of atom bonded with
   conn(j)%vector(bonds(j)) = i               !for each atom involved
```

```
   ENDIF
  ENDDO
 ENDDO
 DO i = 1, N                                          !determine if bond is formed with
                                                      !atoms outside the unit cell
  DO j = 1, N                                         !in the x direction
   xtemp = x(j) + Sx
   r = sqrt( (x(i)-xtemp)**2 + (y(i)-y(j))**2 + (z(i)-z(j))**2 )
   IF (r <= 1.2*r_equi) THEN
    bond_num = bond_num + 1
    bonds(i) = bonds(i) + 1
    bonds(j) = bonds(j) + 1
    conn(i)%vector(bonds(i)) = -j                     !negative means bond outside
    conn(j)%vector(bonds(j)) = -i                     !of unit cell
   ENDIF
  ENDDO
  DO j = 1, N                    !in the y direction
   ytemp = y(j) + Sy
   r = sqrt( (x(i)-x(j))**2 + (y(i)-ytemp)**2 + (z(i)-z(j))**2 )
   IF (r <= 1.2*r_equi) THEN
    bond_num = bond_num + 1
    bonds(i) = bonds(i) + 1
    bonds(j) = bonds(j) + 1
    conn(i)%vector(bonds(i)) = -j
    conn(j)%vector(bonds(j)) = -i
   ENDIF
  ENDDO
  DO j = 1, N                                         !in the z direction
   ztemp = z(j) + Sz
   r = sqrt( (x(i)-x(j))**2 + (y(i)-y(j))**2 + (z(i)-ztemp)**2 )
   IF (r <= 1.2*r_equi) THEN
    bond_num = bond_num + 1
    bonds(i) = bonds(i) + 1
    bonds(j) = bonds(j) + 1
    conn(i)%vector(bonds(i)) = -j
    conn(j)%vector(bonds(j)) = -i
   ENDIF
  ENDDO
 ENDDO
 DO i = 1, N                                          !account for dangling bonds
  IF (species(i)=='As') THEN
   SELECT CASE (bonds(i))
   CASE (1)
    bond_num = bond_num + 3
   CASE (2)
    bond_num = bond_num + 2
   CASE (3)
    bond_num = bond_num + 1
   END SELECT
  ENDIF
 ENDDO
 END SUBROUTINE find_bond_num
```

```
SUBROUTINE calculate                                    !find bond lengths and angles
USE work
IMPLICIT NONE
REAL,ALLOCATABLE :: bond_length(:,:)                    !length of bond
REAL,ALLOCATABLE :: bond_angle(:,:,:)                   !length of bond angle
INTEGER :: error                                        !allocate variable
REAL*8 :: r                                             !Distance between atoms
REAL*8 :: r_equi                                        !bond equillibrium
INTEGER :: i, a, b, j, k                                !loop counters
REAL :: jx, jy, jz, kx, ky, kz                          !temporary positions
REAL :: bond_angle_degrees                              !bond angle in degrees

ALLOCATE (bond_length(N,N), STAT=error)                 !allocate arrays
IF (error/=0) THEN
 PRINT *, 'Could not allocate space for bond lengths.'
 STOP
ENDIF
ALLOCATE (bond_angle(N,N,N), STAT=error)
IF (error/=0) THEN
 PRINT *, 'Could not allocate space for bond lengths.'
 STOP
ENDIF
OPEN (UNIT=20, FILE="lengths")                          !open files
OPEN (UNIT=21, FILE="angles")
r_equi = 5.6 * sqrt(3.0/16.0)
DO i = 1, N                                             !initiallize arrays
 DO j = 1, N
  bond_length(i,j) = 0
  DO k = 1, N
   bond_angle(i,j,k) = 0
  ENDDO
 ENDDO
ENDDO
DO i = 1, N-1                                           !avoid double counting
 DO j = i+1, N                                          !write bond length to file
  r = sqrt( (x(i)-x(j))**2 + (y(i)-y(j))**2 + (z(i)-z(j))**2 )
  IF (r<=1.2*r_equi) THEN
   bond_length(i,j) = r
   bond_length(j,i) = r
   WRITE(20, FMT='(2I4,1f10.4)') i, j, bond_length(i,j)     !writes to file
  ENDIF                                                 !lengths
 ENDDO
ENDDO
WRITE (21,*) '  Angle     Radians    Degrees'
DO i = 1, N                                             !find bond angles
 DO a = 1, 4
  DO b = a+1, 5
   j = conn(i)%vector(a)                                !read 2 atom numbers in angle
   k = conn(i)%vector(b)
   IF (k<=0) THEN                                       !if atom outside unit cell:exit
    EXIT
   ENDIF
```

```
    jx = x(j) - x(i)                                    !moves configuration to origin
    jy = y(j) - y(i)
    jz = z(j) - z(i)
    kx = x(k) - x(i)
    ky = y(k) - y(i)
    kz = z(k) - z(i)
    bond_angle(j,i,k) = acos((jx*kx+jy*ky+jz*kz)/(bond_length(j,i)*bond_length(i,k)))      !calculate bond angle
    bond_angle_degrees = (bond_angle(j,i,k) * (180/3.141592654))
    WRITE(21, FMT='(3I4,F10.4,4X,F10.4)') j, i, k, bond_angle(j,i,k), bond_angle_degrees   !Write to file angles
   ENDDO
  ENDDO
ENDDO

END SUBROUTINE calculate

SUBROUTINE output                                       !screen output
USE work
IMPLICIT NONE
INTEGER :: i
REAL*8 :: electrons_real, bonds_real                    !real values for electron_num
                                                       !& bond_num
INTEGER :: violators                                    !number of incorrect electrons
REAL*8 :: energy                                        !total extra/missing energy

electrons_real = real(electron_num)                     !convert integer value to real
bonds_real = real(bond_num)
PRINT *, 'Number of bonds containing electrons is: ', bond_num
PRINT *, 'Number of electrons: ', electron_num
violators = abs(electron_num-(2*bond_num))     !find # of violators
IF (electrons_real/bonds_real==2) THEN
  PRINT *, 'The electron counting rule has been obeyed'
ELSEIF (electrons_real/bonds_real>2) THEN
  PRINT *, 'There are', violators, ' extra electrons, the electron counting rule has been violated.'
ELSE
  PRINT *, 'There are', violators,' missing electrons, the electron counting rule has been violated.'
ENDIF
energy = 0.4 * violators
PRINT *, 'Additional energy is equivalent to ', energy,' eV'

END SUBROUTINE output
```

Appendix B -- Sample Xmol File

Xmol File(Positions.ecr):

4

Ga 0.960982978 15.219599724 6.992919922 0.0
Ga 8.951292992 15.219599724 6.992919922 0.0
Ga 8.951292992 3.234169960 6.992919922 0.0
Ga 0.960982978 3.234169960 6.992919922 0.0

Cell Parameter File(Cell.ecr):
15.9806 15.9806 15.9806

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*Tomonori Ito, Appl. Phys. **77** (10), 4845 (1995)*
*J. E. Northrup, S. Froyen, Phys. Rev. Lett., **71**, 2276 (1993)*

Webreference:
http://www.physics.ohio-state.edu/~brettrb

Webreference:
http://www.rdl.com/

MY SUMMER TOUR AT THE AIR FORCE RESEARCH LABORATORY

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
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And

Wright Laboratory

August 1998

My Summer Tour at the Air Force Research Laboratory

Jeffrey S. Becknell
Beavercreek High School

Abstract

My summer tour was at the Air Force Research Laboratory, specifically the Air Vehicle Simulation Group. This group was responsible for the simulation of research and development aircraft. When I started to work, they were working to acquire a new visual display system. I performed many tasks while on my tour at the Air Force Research Lab. Among these are working on the new visual display system, the plotting of data, the drawing of simulator diagrams, web authoring, and data cataloging for the reference library.

My Summer Tour
at the
Air Force Research
Wright Patterson AFB

Jeffrey S. Becknell

Introduction

My summer tour was a great place to gain the knowledge and experience I will need in the work place. While I was at Air Force Research, I worked on a wide variety of projects and jobs that needed to be done. These jobs included plotting data, drawing diagrams, web authoring, data cataloging, and working on a new visual display system. I thoroughly enjoyed the time I spent working on these projects.

My Summer Tour

One of the main things that I worked on was the creation of a facility Intranet. This miniaturized Internet was designed to enhance the transfer of information throughout the group. To do this I had to learn the HyperText Markup Language, or HTML. I used this language to write the pages for the Intranet. The Intranet consisted of a basic comprehensive schedule with which to plan all the events that happen, budget information, security procedures, reference library, work orders, and project cost estimator. I used the Microsoft program, Microsoft Scheduler, as the base program that everyone could access on their own system. The schedules for all the current and upcoming events were placed on this so that everybody had easy access to it. I also worked on a reference library that was incorporated into the Intranet. I had to catalog technical manuals and aerospace documents that dated back to the nineteen sixties. I was then going to enter all the titles, dates, authors, and other information in to the Intranet index. Here the users would have been able to look up a particular topic and then find additional information on it. Unfortunately, I was forced to stop work on that because my tour was ending very shortly. The Intranet was designed to be user friendly and easily accessible to the people who would be using it.

One of the jobs that I learned early on was the plotting of data . My mentor gave me the numbers to plot and I plotted them. I plotted several diagrams of the new visual display system. This is another type of simulator that is being developed here at the Dynamics Directorate. It involves the use of mirrors and projectors that are designed to produce higher resolution. I combined the designs of a F-16 cockpit with the new visual display system and converted them to the same scale so we could mount the two items together. My mentor used these designs to take care of the preparation for mounting the two items. The Air Vehicle Simulation group had not yet received the EVE display system because it was in storage elsewhere.

In relation to the new visual display system, I plotted data for two simulators running simultaneously. I was plotting the transfer rate of data between the two simulators. My mentor gave me the data, and then I would normalize the data. After I was done, I would turn it over to my mentor. Although I did not completely understand all the data that I was plotting, I could get the main ideas and work with my mentor on what he wanted done.

All in all, I learned quite a bit, and gained some valuable experience. I enjoyed working with my mentor, hearing the information he had to share with me. I learned many things that I will be able to use in my future work place, including HTML language, the application TurboCAD, and Microsoft Excel. The tour increased my overall general knowledge of the research and development process and of computers in general. I would like to apply again to the program next year if the opportunity presents itself.

TRACE METALS ANALYSIS OF SOIL AND WATER AT MUNITIONS TEST SITES

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Final Report for:
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August 1998

TRACE METALS ANALYSIS OF SOIL AND WATER AT MUNITIONS TEST SITES

Beth Ann Behr
Niceville High School

Abstract

Over the past 60 years, Eglin Air Force Base has conducted munitions testing not only to test the capabilities of new munitions, but also the longevity of munitions stored in arsenals. When munitions are detonated or fired, various metals from components and casings impact the test range environment. Over time, metal fragments become part of the soil profile. Constant munitions testing at Eglin AFB test sites exposes the environment to different metals it would not normally be exposed to. The possibility exists that these metals could reach very high concentrations and eventually contaminate the soil. In order to prevent unacceptable contamination, test sites are being monitored for high concentrations of metals.

Two test sites (C-64A & C) in the Advanced Warhead Evaluation Facility (AWEF) were chosen as monitoring sites for this project. Water samples were taken from the six wells located around C-64C, and 45 soil samples were taken from site C-64A. The soil and water samples were then analyzed with an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

The results of the analysis show that neither C-64A nor C-64C contain unacceptable amounts of the metals analyzed. The results from this analysis will be used as a base line for comparison for future monitoring programs.

TRACE METALS ANALYSIS OF
SOIL AND WATER AT
MUNITIONS TEST SITES

Beth Ann Behr

Introduction:

Monitoring the metals content of soil and water throughout the Eglin Reservation is a necessary duty in order to ensure the safety of the environment. With constant munitions testing in certain ranges, there is concern that the metals concentrations of the soil and water may be largely increased. In response to this, test sites are being monitored to keep aware of current or future changes in the soil/water content.

The purpose of this project was to determine elemental concentrations of Copper, Zinc, Boron, Manganese, Cadmium, Chromium, Nickel, Cobalt, Arsenic, Aluminum, Lead, Tungsten, Tantalum, Uranium, and Iron in soil and water at C-64A & C on Eglin Air Force Base. These elements were chosen due to their present or previous use in the munitions being tested at these areas. The results from this project will be used as a baseline for comparison with future analyses.

Problem Discussion:

The main component of this project was to analyze for metals using the ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer). The ICP operates on the basis that each element has its own characteristic set of energy levels and thus its own unique set of absorption and emission wavelengths. The sample being analyzed is pumped into the instrument in liquid form using a peristaltic pump. The sample is then nebulized, where the liquid sample is exposed to a strong blast of gasses and then turns into an aerosol form. The aerosol then travels to the plasma torch where the atoms in the sample become excited and emit their own characteristic radiation. The spectrometer, which is essentially a varied group of mirrors, collects and sorts the radiation by wavelength. The photo multiplier tube (PMT) measures the intensity of each element and sends the information to the computer (Boss and Kenneth, 1997).

Before performing the analysis using the ICP, the computer must be programmed. The ICP must be told which elements it is looking for. In addition to this, because the ICP works by measuring different wavelengths, the instrument operator must select which wavelengths are most suitable for detection during the analysis. Each element has a multiple of characteristic wavelengths. By choosing specific wavelengths, interferences can be avoided. Blanks and standards must be prepared and analyzed by the ICP as well. This is for the purpose of calibration and obtaining accurate results.

An interferences is anything that causes the detected concentration of an analyte in a sample (the element being measured) to be different from the actual concentration in that sample. Different types of interferences are wavelength interferences, matrix interferences, and physical interferences. Interferences can be detected through certain quality control procedures, such as using spikes or duplicates and by viewing the spectra result of the analysis.

Spikes are created by taking two samples of identical origin and "spiking" one with a known amount of a certain element. If no interferences are present in the sample, then the results of the spiked sample will be equal to the amount of element added to the original sample. Analyzing duplicate samples is another quality control procedure. The results of the analysis on these samples should be very similar to identical. If the spiked samples are not that known amount higher than the original samples or if the results of the duplicate samples are not similar, then we can ascertain that either interferences are present or there was an error in the

preparation of the samples. When viewing the spectra result of the analysis, one can also tell if the instrument has received an accurate reading or a reading with interferences.

In addition to changing the wavelengths the instrument is looking for, matrix modifiers can be used and chemicals can be added to the samples to bring out other elements being hidden. Blanks are samples that are run through the instrument in order to correct for elements inadvertently added by the atmosphere and glassware. A blank consists of everything that was added to the sample to prepare it for the ICP, but not the sample itself. In this project, for example, the blank consisted of 20 mL HNO_3 and 11 mL HCl and distilled water. This way, the instrument will analyze the sample, and not what was added to it. An example of a chemical used to correct for interferences is lanthanum. When iron and aluminum are present in high concentrations in a sample, they can sometimes suppress other elements in the same sample. When lanthanum is added, it absorbs the wavelengths of iron and aluminum, and the other elements can then be detected.

Methodology:

All procedures are followed in accordance with the USEPA "Standard Methods for the Examination of Water and Waste-Water, and the USEPA" Methods for the Determination of Metals in Environmental Samples, (method 200) (Greenberg et al, 1992).

Sample Collection and Preservation:

Water:

Glass jars were used as the collection containers for the water samples. In order to ensure that the jars were clean for the collection of the water, they were acid rinsed with 10 mL of HNO_3 and water. They were allowed to soak in this solution over night, and then they were triple rinsed using distilled water.

The water samples were collected from six monitoring wells located around site C-64C. The monitoring wells were installed at this test site prior to this project in order to allow water in the area to be sampled as part of the radioactive materials permit. A bailer was used to collect samples from the wells. One sample was collected from all five wells except for MW2 (monitoring well #2). Two samples were collected from MW2. This well was randomly chosen out of the six in order to have a duplicate sample for quality control.

In order to guarantee the most accurate analyses possible, preservation measures were taken to ensure the sample did not change from the time of collection to the time of analysis. To preserve the water samples, 10mL of HNO_3 were added to each sample in order to maintain a pH of less than 2.0. Lowering the pH keeps the metals in an ionic form which prevents any adsorption of the metals onto the glass jars in which they are stored. The samples were then stored at 4.4°C until they were analyzed. Samples were stored at this temperature to minimize evaporation and chemical reactions. Evaporation would cause the metals in the samples to become more concentrated. This would result in inaccurate metals readings.

Soil:

Plastic bags were used as collection containers for the soil samples. A shovel was used to collect the 0-5cm samples and an auger was used to collect the deeper samples. The soil samples did not require any special steps for preservation. In order to evenly sample the test site, a sampling array was established. This array consisted of three concentric circles with radii 3m, 12m, and 36m, a center point, and two control sites. The center point of the grid was located at the lowest elevation point at the test site. Sampling points were located on each of the concentric circles as shown in figure I. At five sampling points and the two control sites, samples

were taken at depths of 0-5cm, 20-25cm and 40-45cm. The purpose of sampling at deeper depths was to check for leaching of the metals through the soil profile.

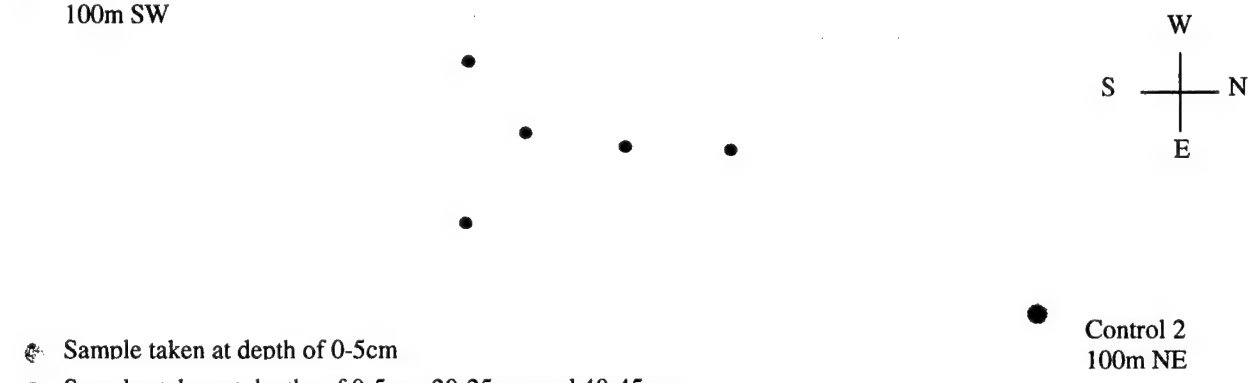


Figure I . Soil Sample Array

Sample Preparation:

Water:

No preparation was required for the water samples before analyzing them using the ICP.

Soil:

All samples being analyzed using the ICP must be in liquid form. Thus, the soil samples required extensive preparation. Approximately one gram of each sample was placed into a volumetric flask (these flasks were also acid rinsed before being used). Since there was great difficulty of measuring out exactly one gram of soil, the weights were recorded for each sample and a correction factor was calculated into the results later using the original weights. Each soil sample was then acid digested.

For the acid digestion, twenty mL of HNO3 were added to each soil sample, and the samples were heated in a water bath of 26.7°C for one and a half hours. The purpose of the water bath was to heat the acid to higher temperatures to speed up chemical reactions. After the first water bath, the samples were allowed to cool, and then 11mL of HCl were added to each flask. The flasks were again placed in a water bath of 26.7°C for 1 hour. After this acid digestion, however, solids were still present in the samples. These solids were assumed to be silicates. The acids used could not digest some of the sediment in the samples. However, acids such as hydrofluoric acid and perchloric acid are capable of digesting such compounds, but are dangerous in nature and are also harmful to the ICP. For this reason, the samples were left as they were after the HNO_3 and HCl digestion. The samples were then diluted up to 100mL with distilled water. They were then allowed to sit overnight so the sediment would settle to the bottom of the flasks. Since the sediment was on the bottom of the flasks, it had a lesser chance of being pumped into the instrument and clogging the thin tubing or the nebulizer.

ICP preparation:

On the computer, a specific wavelength was selected for each of the fifteen elements. The blank was then analyzed by the instrument for the purpose of calibration. Then 100ppm standards were also run to calibrate the instrument. The different samples, including their duplicates and spikes, were then analyzed using the ICP. The results of each analysis were compared. When the spiked samples revealed interferences, a new wavelength was chosen. Then the samples were analyzed again using the new wavelength. When wavelength alteration was not successful, chemical correction was used. Lanthanum was added to each of the

samples in order to absorb the iron and aluminum wavelengths. The ICP was then able to detect the wavelengths of the other elements.

Changing wavelengths was required for correcting the interferences in the water samples. For the soil samples, however, due to the complex matrix of the soil, merely changing wavelengths was not adequate. Lanthanum was needed to correct for the interferences. Once lanthanum was added to each sample, the instrument was able to give more accurate results. At this time, however, the instrument malfunctioned and the analyses with the lanthanum added to each sample were not completed. Therefore, results were obtained for the concentration of all fifteen elements in the water samples, but only results for Cu, Zn, B, Mn, Cd, Cr, and Ni were obtained for the soil samples. The results from the analyses and their corresponding wavelengths are given in charts II-III.

Table II Water Analysis Data in mg/L

Sample ID		MW1 Mg/L	MW2 Mg/L	MW3 Mg/L	MW4 Mg/L	MW5 Mg/L	MW6 Mg/L
Element	Symbol & wavelength (nm)						
Chromium	Cr 283.563	BDL	BDL	BDL	BDL	BDL	BDL
Uranium	U 367.007	BDL	BDL	BDL	BDL	BDL	BDL
Arsenic	As 188.979	BDL	BDL	BDL	BDL	BDL	BDL
Lead	Pb 220.353	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium	Cd 214.44	0	0.001	0	0	0	0
Iron	Fe 238.204	BDL	BDL	BDL	BDL	BDL	BDL
Cobalt	Co 228.616	0.001	0.005	0.001	0.001	0.002	0.001
Nickel	Ni 341.476	BDL	BDL	BDL	BDL	BDL	BDL
Copper	Cu 324.752	BDL	BDL	BDL	BDL	BDL	BDL
Zinc	Zn 206.2	0.001	0.022	BDL	BDL	BDL	BDL
Aluminum	Al 308.215	4.49	0.379	0.02	0.149	0.35	0.008
Boron	B 249.772	0.029	0.021	0.014	0.01	0.009	0.003
Tungsten	W 239.708	0.018	0.009	0.017	0.01	0.007	0.007
Tantalum	Ta 240.063	BDL	BDL	BDL	BDL	BDL	BDL
Manganese	Mn 257.61	0.002	0.556	0	0.047	BDL	0.013

Table III Soil Analysis Data in mg/Kg

Element & Wavelength (nm)	Chromium 283.563	Nickel 341.48	Copper 324.75	Zinc 206.2	Boron 249.772	Manganese 257.61	Cadmium 228.802
Sample ID	Cr	Ni	Cu	Zn	B	Mn	Cd
Center Point corrected	0.610	0.116	0.252	0.152	0.746	1.432	0.002
A-1-a corrected	0.300	0.052	0.094	0.124	0.434	1.478	0.002
A-1-b corrected	0.021	0.003	BDL	BDL	0.123	1.135	BDL
A-1-c corrected	0.034	0.014	BDL	BDL	0.079	0.501	BDL
A-2 corrected	0.604	0.117	0.122	0.194	0.676	1.830	0.002
A-3-a corrected	0.110	0.019	BDL	BDL	0.166	1.696	0.000
A-3-b corrected	0.016	0.003	BDL	BDL	0.068	1.897	BDL
A-4 corrected	0.341	0.064	BDL	0.131	0.421	1.449	0.001
B-1-a corrected	0.376	0.067	0.036	0.096	0.424	1.507	0.003
B-1-b corrected	0.000	0.000	BDL	BDL	0.060	1.235	BDL
B-1-c corrected	0.015	0.006	BDL	BDL	0.038	0.593	BDL
B-2 corrected	0.122	0.021	BDL	0.036	0.240	1.069	0.001
B-3 corrected	0.160	0.043	BDL	0.049	0.231	0.950	0.003
B-4-a corrected	0.108	0.026	BDL	0.053	0.156	1.081	0.002
B-4-b corrected	BDL	0.003	BDL	0.016	0.018	1.324	BDL
B-4-c corrected	BDL	0.003	BDL	0.018	0.014	1.081	0.000
B-5 corrected	0.068	0.017	BDL	0.000	0.104	0.837	0.001
B-6-a corrected	0.140	0.037	BDL	0.064	0.169	0.988	0.001
B-6-b corrected	BDL	0.009	BDL	BDL	0.009	1.035	BDL
B-6-c corrected	BDL	0.004	BDL	BDL	0.000	0.500	BDL
B-7 corrected	0.441	0.094	0.094	0.189	0.464	1.594	0.005
B-8 corrected	0.595	0.115	0.133	0.296	0.641	1.701	0.005
C-1 corrected	0.148	0.030	0.060	0.030	0.578	0.326	0.007
C-2 corrected	0.060	0.007	0.031	0.007	0.236	0.178	0.002

Table III Soil Analysis Data in mg/Kg (continued)

Element & Wavelength (nm)	Chromium 283.563	Nickel 341.48	Copper 324.75	Zinc 206.2	Boron 249.772	Manganese 257.61	Cadmium 228.802
Sample ID	Cr	Ni	Cu	Zn	B	Mn	Cd
C-3 corrected	0.091	0.012	0.041	0.023	0.220	0.278	0.001
C-4 corrected	0.125	0.015	0.034	0.009	0.228	0.289	0.001
C-5 corrected	0.084	0.011	0.021	BDL	0.146	0.144	0.000
C-6 corrected	0.119	0.029	0.035	0.005	0.173	0.203	0.000
C-7 corrected	0.126	0.018	0.055	0.018	0.194	0.466	0.001
C-8 corrected	0.160	0.024	0.069	0.030	0.206	0.800	0.001
C-10 corrected	0.807	0.195	0.478	0.300	0.862	1.922	0.006
C-11 corrected	0.297	0.045	0.102	0.159	0.816	0.003	0.039
C-12 corrected	0.353	0.060	0.207	0.145	0.399	1.351	0.004
C-13 corrected	0.125	0.032	0.028	0.010	0.098	0.151	0.000
C-14 corrected	0.132	0.027	0.041	0.673	0.144	0.471	0.002
C-15 corrected	0.078	0.007	0.035	0.043	0.084	0.793	0.000
C-16 corrected	0.190	0.016	0.126	0.060	0.207	0.997	0.000
Control 1A corrected	0.082	0.003	0.026	BDL	0.123	0.985	BDL
Control 1B corrected	0.059	0.003	0.020	BDL	0.070	1.149	BDL
Control 1C corrected	0.058	0.004	0.019	BDL	0.049	0.672	BDL
Control 2A corrected	0.059	0.002	0.021	BDL	0.035	0.315	BDL
Control 2B corrected	0.051	0.006	0.015	BDL	0.028	0.174	BDL
Control 2C corrected	0.052	BDL	0.014	BDL	0.016	0.126	BDL

Water Analysis Results

The following graphs display the concentrations of each element in each monitoring well. Some of the bars on the graph drop below the 0ppm line to a line labeled BDL (below detection limit). The detection limit of the instrument is determined through calculations using the parts per million (ppm) standard used to calibrate the machine, and the ppm of the spikes used. In the case of this project, 100ppm standards were used and 1ppm spikes were used. Thus, the detection limit for the analyses in this project is 1ppm. Below Detection Limit reading indicates that the instrument can detect traces of the element in the sample, but can not give an accurate reading of how much of that element is actually present.

Figure IV
Water Results for Zn, B, Mn, Cd, and Cr

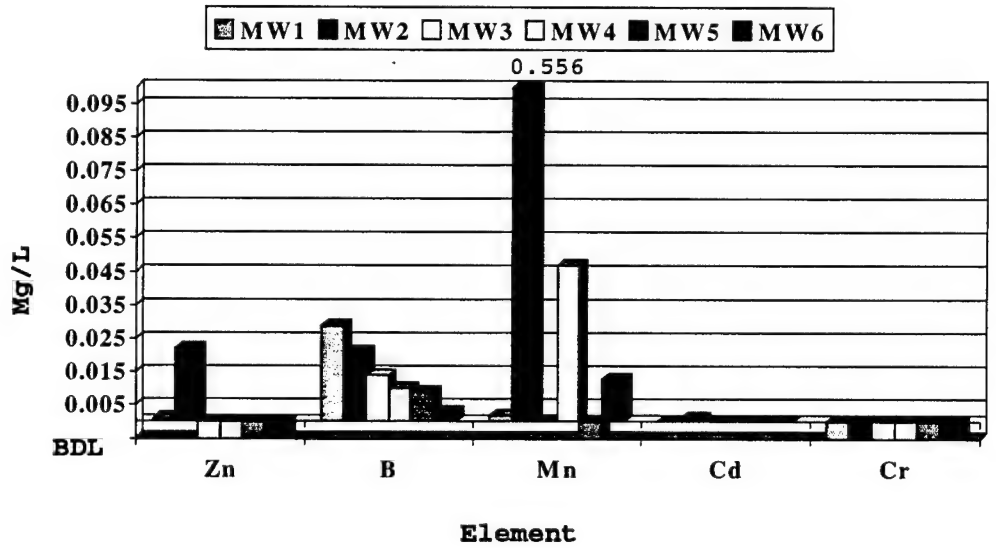


Figure V
Water Results for Ni, Co, As, Al, and Pb

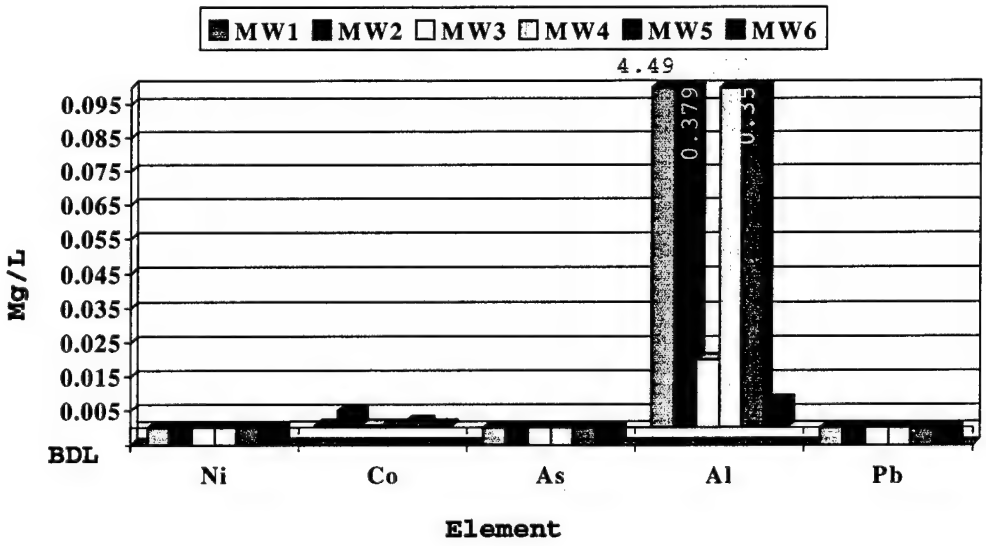
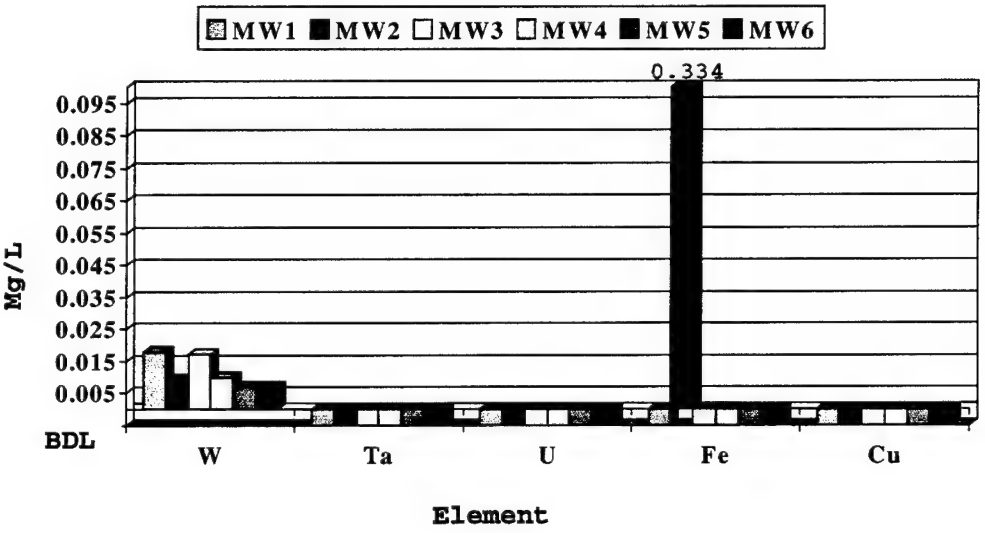


Figure VI
Water Results for W, Ta, U, Fe, and Cu

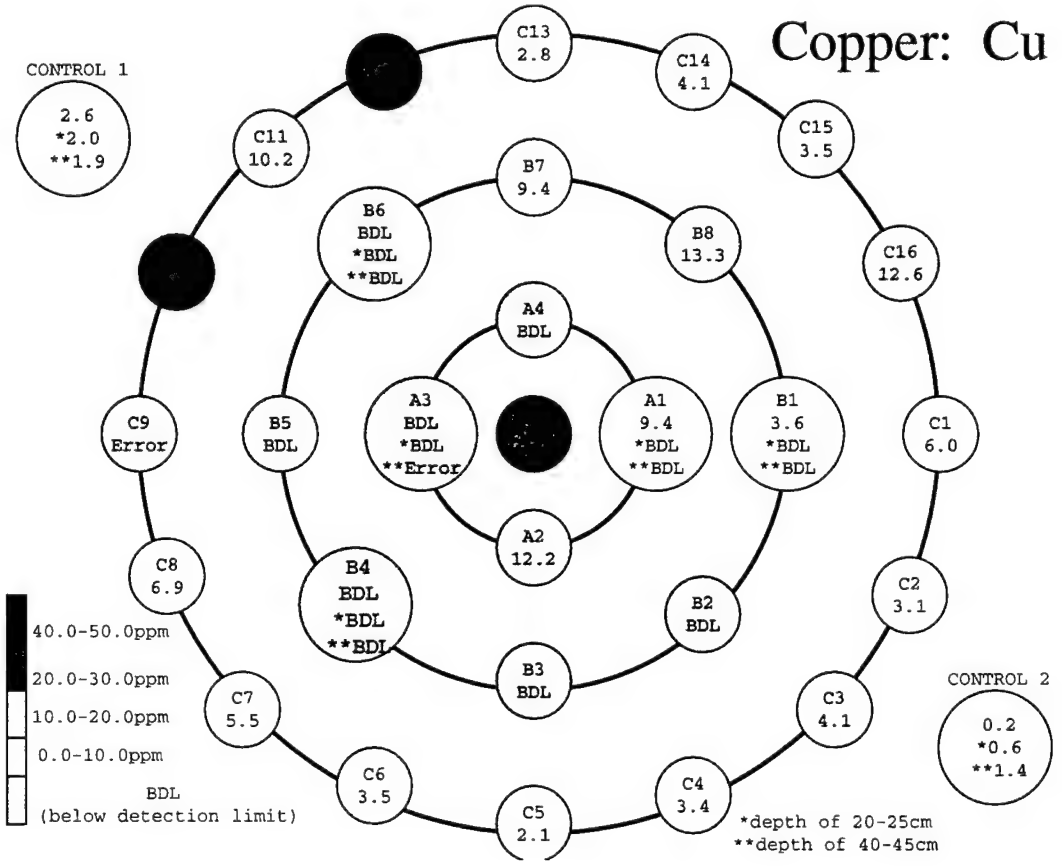


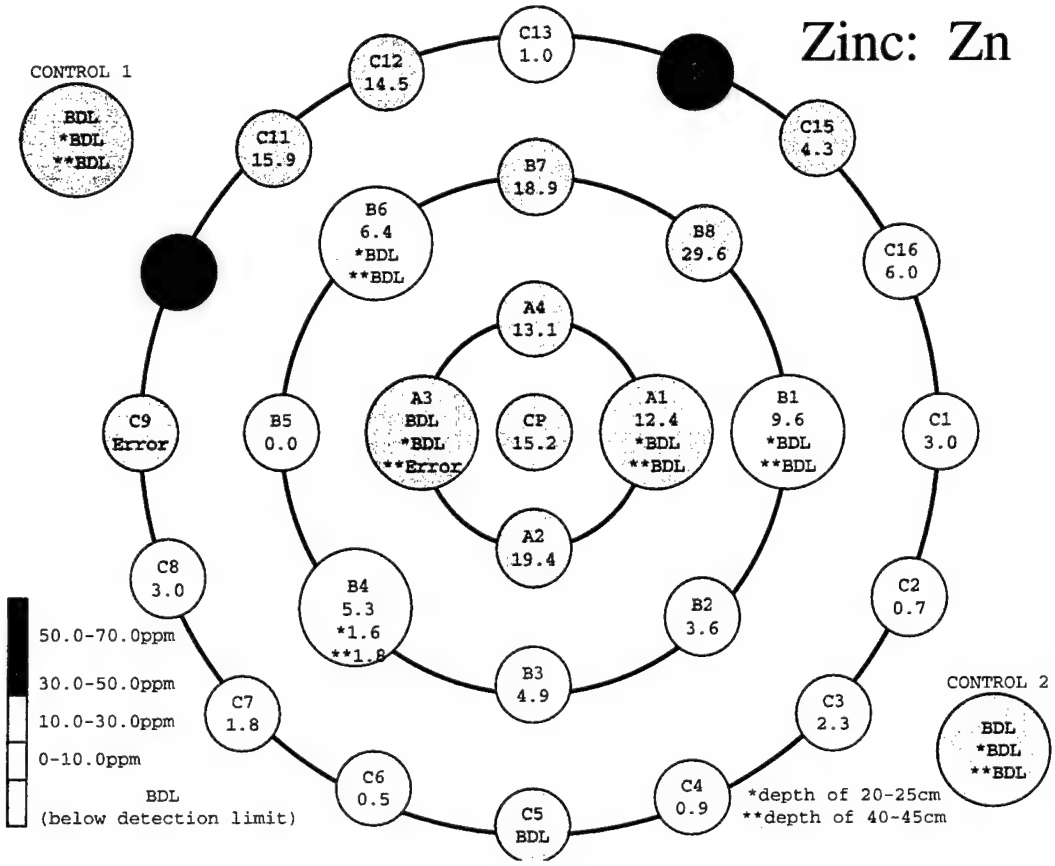
Soil Analysis Results:

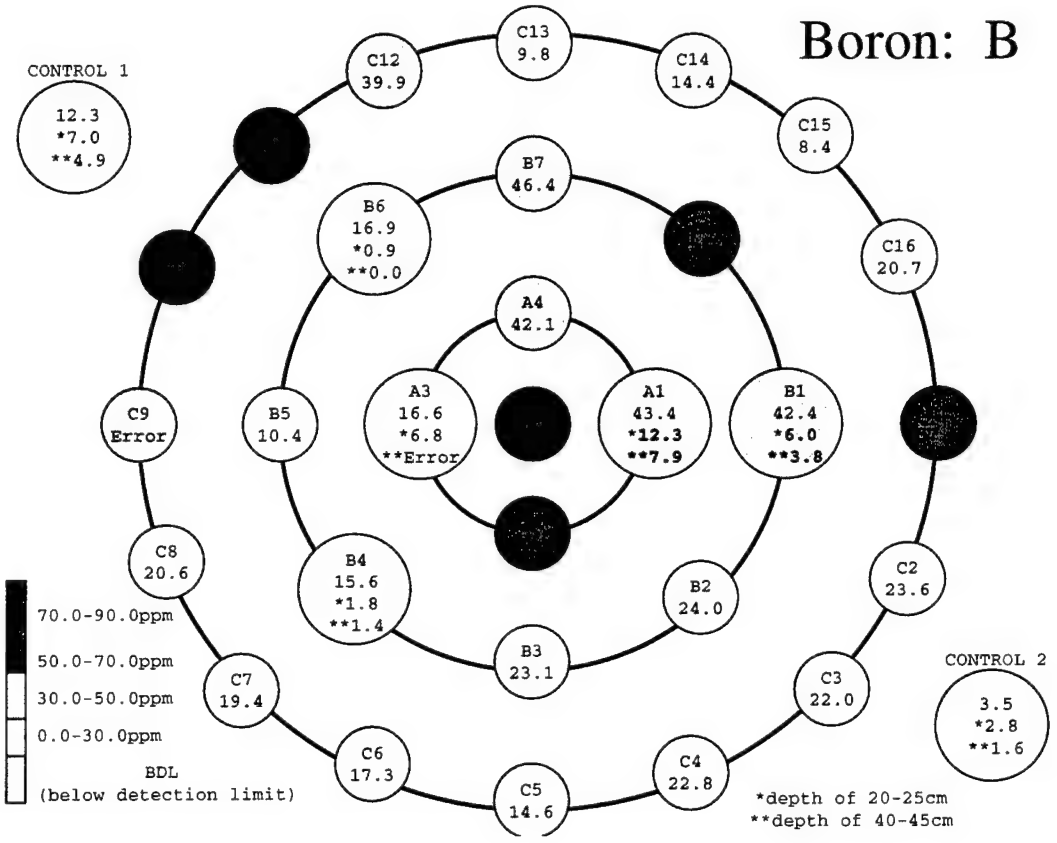
The following graphs give the soil analyses results for each element in the form of the sampling array. Each circle represents a different sampling location on the grid. Inside each circle is the concentration of each element in ppm. The larger circles with three readings are the locations where samples were taken at the surface, at 20-25cm and at 40-45cm respectively. The different shades represent the concentration level of each element. The darker the shade, the higher the concentration of the element.

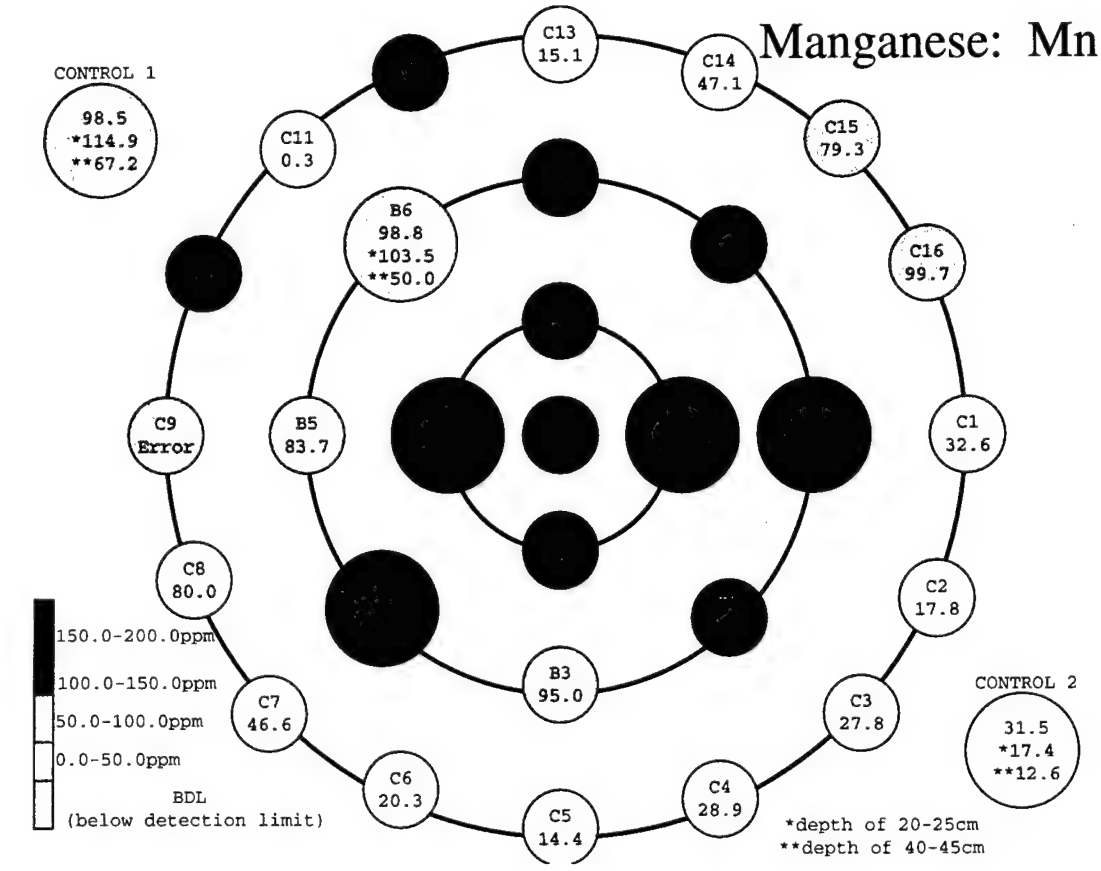
A scale at the bottom left hand corner of each chart explains which shade represents which element concentration. Note that each shade scale is individual to each chart. Also, none of the shades chosen represent a danger level. The dark shades, for example, signify that those sample locations have a higher amount of an element compared to other sample locations in the array. This does not mean that the concentration is at an unacceptable level.

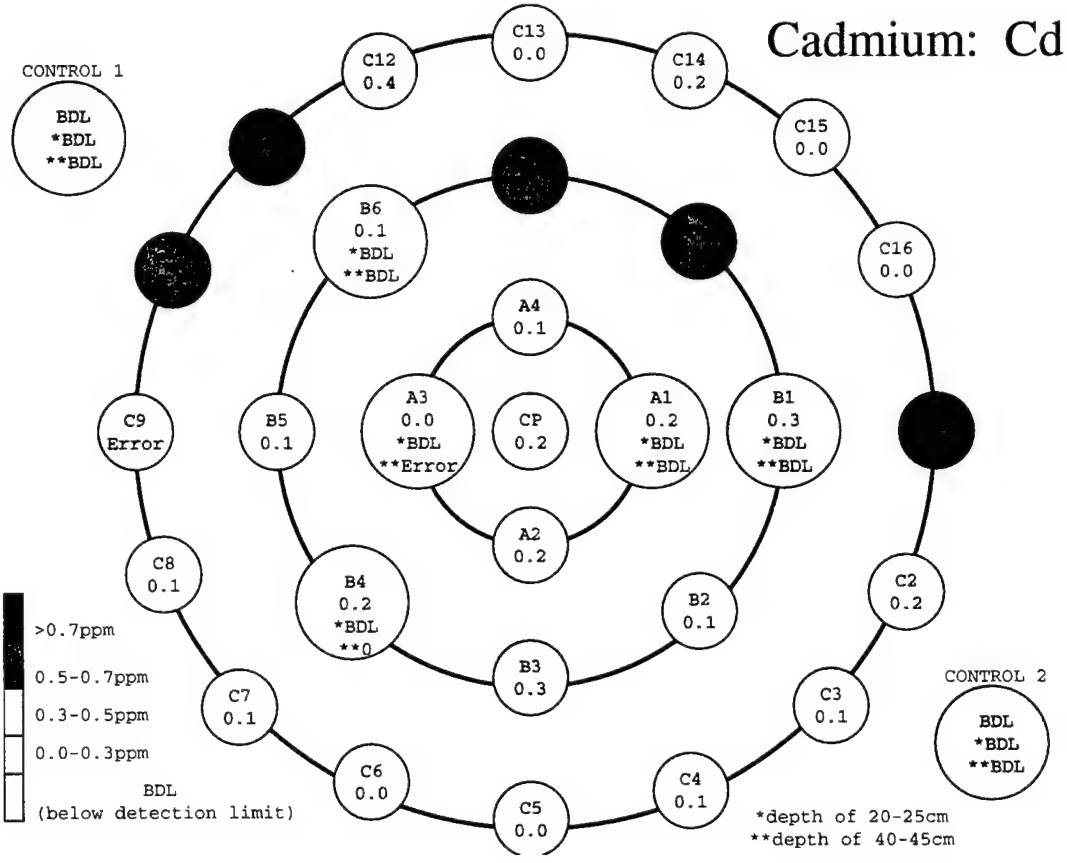
There are also circles which represent readings of BDL (below the detection limit). This is the same as with the water, where the instrument could tell that the element was present, but was unable to determine exactly how much. The chart reads "error" at sample locations C-9 and A-3C. This was due to the fact that during sample preparation, these samples were contaminated and were never analyzed.

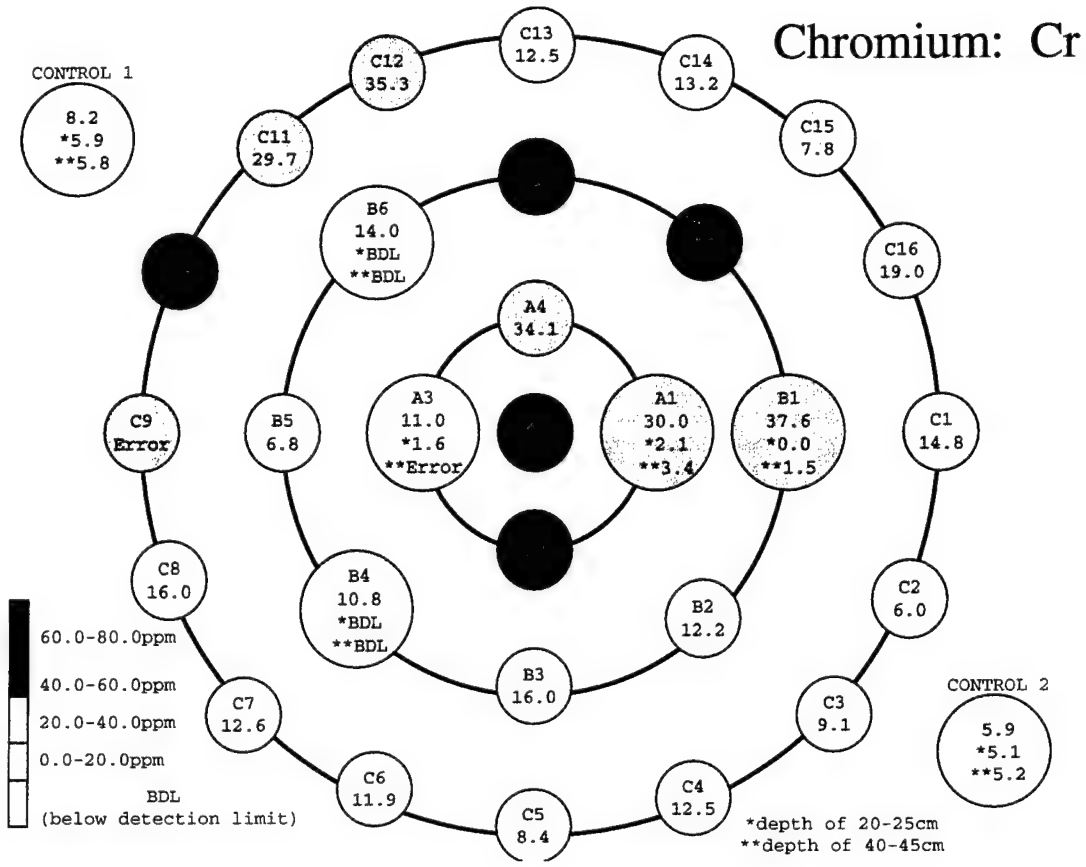


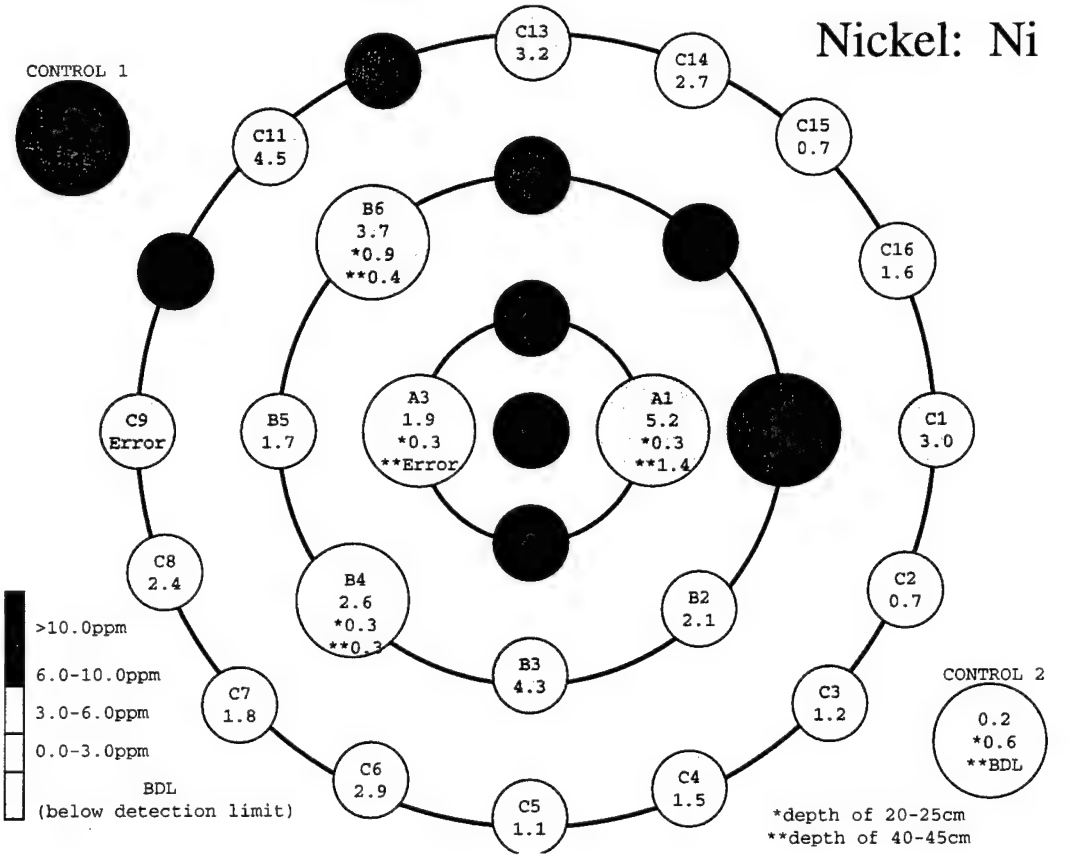

Zinc: Zn
CONTROL 1
BDL
*BDL
**BDL
C13
1.0
C12
14.5
C11
15.9
C15
4.3
B7
18.9
B6
6.4
*BDL
**BDL
B8
29.6
C16
6.0
A4
13.1
A3
BDL
*BDL
**Error
CP
15.2
A1
12.4
*BDL
**BDL
B1
9.6
*BDL
**BDL
C9
Error
B5
0.0
C1
3.0
A2
19.4
C8
3.0
B4
5.3
*1.6
**1.8
B2
3.6
C2
0.7
B3
4.9
C7
1.8
C3
2.3
CONTROL 2
BDL
*BDL
**BDL
C6
0.5
C4
0.9
C5
BDL
50.0-70.0ppm
30.0-50.0ppm
10.0-30.0ppm
0-10.0ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm


Boron: B
CONTROL 1
12.3
*7.0
**4.9
C13
9.8
C12
39.9
C14
14.4
C15
8.4
B7
46.4
B6
16.9
*0.9
**0.0
C16
20.7
A4
42.1
A3
16.6
*6.8
**Error
A1
43.4
*12.3
**7.9
B1
42.4
*6.0
**3.8
C9
Error
B5
10.4
C8
20.6
B4
15.6
*1.8
**1.4
B2
24.0
C2
23.6
B3
23.1
C7
19.4
C3
22.0
CONTROL 2
3.5
*2.8
**1.6
C6
17.3
C4
22.8
C5
14.6
70.0-90.0ppm
50.0-70.0ppm
30.0-50.0ppm
0.0-30.0ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm


Manganese: Mn
CONTROL 1
98.5
*114.9
**67.2
C13
15.1
C14
47.1
C15
79.3
C16
99.7
C1
32.6
C2
17.8
C3
27.8
C4
28.9
C5
14.4
C6
20.3
C7
46.6
C8
80.0
C9
Error
C11
0.3
B6
98.8
*103.5
**50.0
B5
83.7
B3
95.0
CONTROL 2
31.5
*17.4
**12.6
150.0-200.0ppm
100.0-150.0ppm
50.0-100.0ppm
0.0-50.0ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm


Cadmium: Cd
CONTROL 1
BDL
*BDL
**BDL
C13
0.0
C12
0.4
C14
0.2
C15
0.0
C16
0.0
C1
0.2
C2
0.2
C3
0.1
C4
0.1
C5
0.0
C6
0.0
C7
0.1
C8
0.1
C9
Error
B6
0.1
*BDL
**BDL
B5
0.1
B4
0.2
*BDL
**0
B3
0.3
B2
0.1
A4
0.1
A3
0.0
*BDL
**Error
CP
0.2
A1
0.2
*BDL
**BDL
B1
0.3
*BDL
**BDL
A2
0.2
CONTROL 2
BDL
*BDL
**BDL
>0.7ppm
0.5-0.7ppm
0.3-0.5ppm
0.0-0.3ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm


Chromium: Cr
CONTROL 1
8.2
*5.9
**5.8
C13 12.5
C14 13.2
C15 7.8
C16 19.0
C1 14.8
C2 6.0
C3 9.1
C4 12.5
C5 8.4
C6 11.9
C7 12.6
C8 16.0
C9 Error
C11 29.7
C12 35.3
B6 14.0 *BDL **BDL
B5 6.8
B4 10.8 *BDL **BDL
B3 16.0
B2 12.2
B1 37.6 *0.0 **1.5
A4 34.1
A3 11.0 *1.6 **Error
A1 30.0 *2.1 **3.4
CONTROL 2
5.9
*5.1
**5.2
60.0-80.0ppm
40.0-60.0ppm
20.0-40.0ppm
0.0-20.0ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm


Nickel: Ni
CONTROL 1
C13 3.2
C14 2.7
C15 0.7
C16 1.6
C1 3.0
C2 0.7
C3 1.2
C4 1.5
C5 1.1
C6 2.9
C7 1.8
C8 2.4
C9 Error
C11 4.5
B6 3.7 *0.9 **0.4
B5 1.7
B4 2.6 *0.3 **0.3
B3 4.3
B2 2.1
A3 1.9 *0.3 **Error
A1 5.2 *0.3 **1.4
CONTROL 2
0.2
*0.6
**BDL
>10.0ppm
6.0-10.0ppm
3.0-6.0ppm
0.0-3.0ppm
BDL
(below detection limit)
*depth of 20-25cm
**depth of 40-45cm

Summary:

Water:

The concentrations of each element from well to well were fairly similar. The only significant observation in the water results was that MW2 (monitoring well #2) seemed to have a higher concentration of analyzed elements than the other five wells. When collecting the water from this well, it was noticed that this well had a higher amount of turbidity than the other wells. This well was also the shallowest of the six wells. Perhaps the higher amount of sediment in the well and the lesser amount of water resulted in higher metal concentrations in the water.

Soil:

There is no obvious pattern among the concentrations of elements in the sample grid at site C-64. It is evident that the higher concentrations of elements seem to be located at the center or to the west of the grid. No dangerously high levels of metals were found.

The concentrations seem to be very localized. The soil result chart of Zinc, for example, shows sample site C13 with a concentration of 1.0 ppm. The sample site next to it (C14) has a concentration of 67.3 ppm. A possible explanation for this high amount of localization is that most of the munitions testing done in this area is done with metal casings which break up into many fragments. A location in the field with a bomb fragment in it is likely to have a higher concentration of metals than a location without a munition fragment.

The charts also reveal that leaching of these metals is occurring. When looking at the multi-depth samples on the Boron chart, for example, it can be seen that the concentration of the elements decreases as the depth increases. Thus, some metals are actively migrating through the soil profile.

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Boss, Charles B. and Fredeen, Kenneth J. "Concepts, Instrumentation, and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry." The Perkin-Elmer Corporation.1997.

Greenberg, Arnold E., Clesceri, Lenore S., Eaton, Andrew D. "Standard Methods for the Examination of Water and Wastewater; 18th Edition 1992." American Public Health Association, American Water Works Association, Water Environment Federation. 1992.

Crystal W. Bhagat's report was not available at the time of publication.

SCANNING AND ORGANIZATION OF REPORTS

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

And

Wright Laboratory

August 1998

SCANNING AND ORGANIZATION OF REPORTS

Christopher J. Broscious
Mosley High School

Abstract

At the soils lab of AFCESA (Air Force Civil Engineer Support Agency), there has been an increasing need to put their Airfield Pavements Evaluations (APE) onto a computer. These evaluations run back as far as 1944 and as soon as 1996. Once these reports are on a computer they can then be transmitted to others at the click of a button through the Internet and may also be edited without damaging the original document. Also new technology has been brought out that will allow a computer to pick out the words from the pictures and spell check those words also.

SCANNING AND ORGANIZATION OF REPORTS

Christopher J. Broscious

Introduction

Scanning has become increasingly significant in our society today. Scanners allow people to scan in their favorite pictures, work documents, and even their own hand, as well as many other things. These are then stored onto a computer hard drive and can be brought back up or sent to other people via e-mail with just a few clicks. Many use these pictures for their web page or print them out so they have and extra in case they lose the first. Since many of the documents held by the AFCESA (Air Force Civil Engineer Support Agency) are becoming old and brittle, a need has arose to put these onto a computer. Once they are onto a computer they can then be brought back up to study, sent to other people around the world, or printed back out to store in a file cabinet. The solution to this problem was scanning.

Methodology

Once the method of getting the documents, Airfield Pavements Evaluation reports in this case, onto a computer was determined, a proper scanner was required. A Hewlett Packard ScanJet 3C scanner was provided by AFCESA, along with the program DeskScan II for the project. This is a high quality scanner allows you to scan either black and white or color text, drawings, and pictures. The DeskScan II software allows you to preview a page, make the scan lighter or darker, enlarge or reduce a scan, and choose how much of the page you need scanned. All of these options came into play at some point during this project and the program proved to be a very easy to use and helpful.

Now that the method of getting the Pavement Evaluations onto the computer had been determined, a way to organize these documents was now needed. A new folder was made in the D drive of the computer with the scanner and scanner software on it. This was to be the main folder where all the individual documents would be stored. More folders were then created using names such as Document 01, Document 02, and so on. These were where the individual documents would be stored to keep them separate from other

documents. Since the names of these folders were not the names of the airfield that was evaluated a key was needed so you could tell which number went to which airfield. For this problem a spreadsheet was created using Microsoft Excel containing the document number, name of the airfield evaluated, and the year that the evaluation was done since some fields have been evaluated more then once. Later a two more columns were added, the first was the number of files or scans it took to copy the evaluation and the other was the size in megabytes of the folder where the document was saved. The number of pages wasn't to important to the project except to tell how many total pages had been scanned. The size of the folder the document was saved in was important because we needed to know how big they were so that when they were ready to be moved to a different computer, the number of zip disk it takes to move them would be known.

Results

With the folders in place and the spreadsheet created it was now time for the scanning process to begin. One of the Airfield Pavements Evaluation reports is obtained and the name and date of the report is recorded into the spreadsheet that was made at the beginning of this project. The staples holding the report together are removed so that the individual pages can be scanned and the title page is place face down on the scanner. A preview of the page is then taken to determine whether the settings need to be changed to make the scan lighter or darker. Preview is also used so you can move the rectangular selection box over the area of the document that you need scanned. You can increase or decrease this area by grabbing the ends of the rectangle. The larger the area inside of the rectangle, the larger the size of the file will be once it has been scanned. A non-rectangular area could also be scanned by holding down the control key while redrawing the selection area with the mouse. Now all that is left to do is scan and save the page into the appropriate folder. All titles pages were saved under the name "Title", and all of the following pages were saved as Pg1, Pg2, Pg3, etc. Some of the pages required two scans to copy the whole page onto the hard drive. In these cases the files were saved as Pg10_1, Pg10_2, etc. Some trouble was encountered with these pages due to the fact that if you halved the paper, some words would be cut short causing only part of

the word to be scanned in. It was not an immediate problem but when the page was spell checked in the future the spell checker might not be able to determine what the exact word was. To combat this problem non-rectangular area was cut, so that the words would not be cut off and would appear fully on one page or the other. The same process of previewing and saving was carried out through all the reports scanned.

Conclusion

A total of fifty-three evaluations and two thousand seven hundred and eighteen pages were scanned into a computer. Still there is still many that have not been scanned yet. Hopefully once these are all scanned in the spell checking process can begin, and the reports can be made available without even having to leave your computer desk. Who knows what other advantages scanning may hold in the future?

References

1.) HP DeskScan II User's Guide, Hewlett Packard Company, October 1994

PRELIMINARY DESIGN OF AN ELECTRICALLY CONDUCTING NITROGEN-BENZENE RING STARBURST DENDRIMER

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Final Report for:
High School Apprentice Program
Wright-Patterson Air Force Base

Sponsored by:
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and
Wright-Patterson Air Force Base

August 1998

PRELIMINARY DESIGN OF AN ELECTRICALLY CONDUCTING NITROGEN, BENZENE RING STARBURST DENDRIMER

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West Carrollton High School

Abstract

Though the first dendrimer was not synthesized until 1984, this relatively new class of molecule shows great potential for applications in a number of fields[1,2] . This paper discusses the development of dendrimers and their potential usage as conducting materials because of their unique three-dimensional, radially symmetrical properties. A starburst dendrimer with an initiator core of ammonia and repeating units of benzene and nitrogen was designed as a possible conducting composite. Utilizing HyperChem® (Autodesk), generations 0-6 in the dendrimer series were modeled. Each generation was then geometrically optimized to produce the most stable conformation of the molecule.

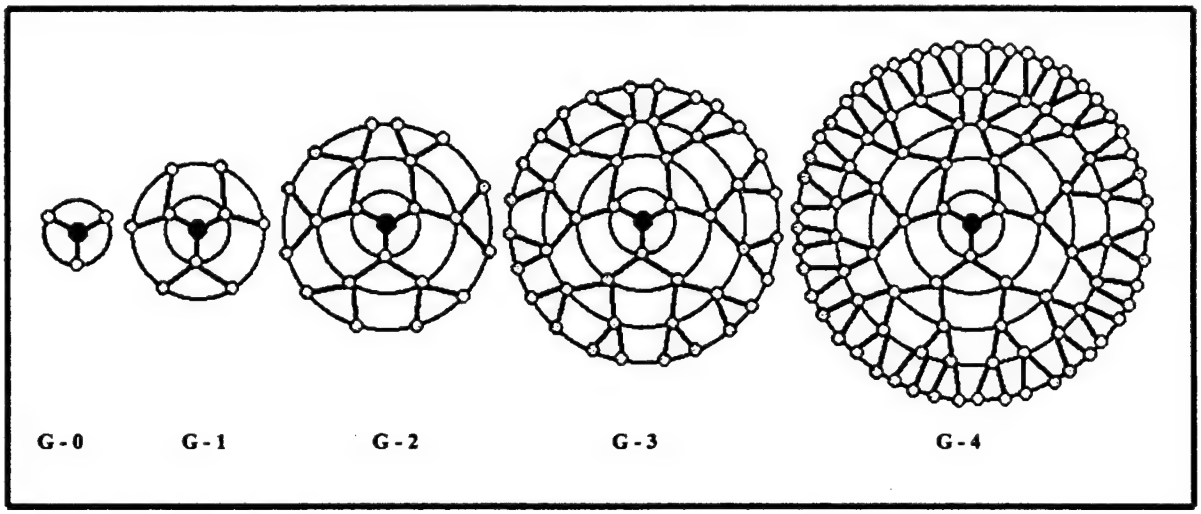
PRELIMINARY DESIGN OF AN ELECTRICALLY CONDUCTING NITROGEN, BENZENE RING STARBURST DENDRIMER

Theresa Diane Carr

Introduction

In recent years, a considerable amount of research has focused on the potential applications of dendrimers. The first conceived functions of these relatively new three-dimensional, radially symmetrical polymers emphasized their usage as biomolecules.[1,2] It is understandingly so, because the structure of starburst dendrimers so closely parallels those observed in biology (branching of trees, development of corals).[3] The ideal configuration of starburst dendrimers is shown in Fig. 1. (Generations 0-4)

Fig. 1. Successive generations (0–4) of ideally formatted starburst dendrimer. Black circle denote initiator core. Gray circles are branch junctures.



The formation of a starburst dendrimer is dependent on a centrally located atom or molecule called an initiator core. Depending on the compound used as the initiator core, three or more repeating units can attach radially forming Generation 0 of the dendrimer. These initial repeating units can be likened to the trunk of an individual tree. Each original repeating unit has the potential to form a branch juncture and bond with, depending on the actual repeating unit used, two or more new repeating units, creating Generation 1 in the series. The dendrimer can continue to add repeating units, forming subsequent branch

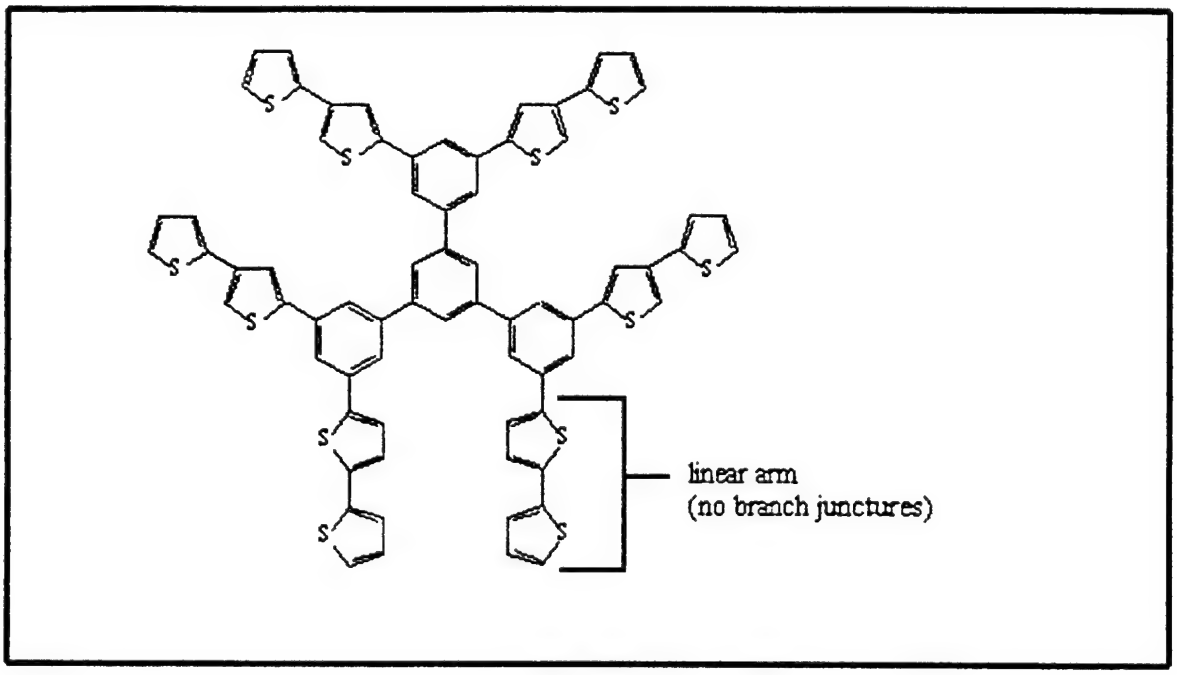
junctures and generations in the series. Each tier in the interior portion of the macromolecule can be equated to a branch of a tree, with the potential of producing more branches. The molecule increases in a geometrically progressive fashion because of its regular, concentric tiers. However, a starburst dendrimer cannot continue to infinite generations. As the dendrimer progresses to the next generation, the number of peripheral repeating units increases exponentially, but the diameter of the molecule can increase only linearly. Eventually it will reach the "starburst limited generation", where branching cannot be regular because the terminal groups on the repeating units are too congested.[3,4]

Starburst dendrimers have received considerable attention by researchers because of their unique three-dimensional structures.[3-6] In generations 0-3 the conformation of the molecule resembles that of a open dome or hemisphere. When the dendrimer reaches generation 4 proportions, it undergoes a morphological change and its structure resembles a sphere, or hollow ball. This spherical shape is made possible because the repeating units used in the branches of the macromolecule are uniform. All paths from units in the same generation to the initiator core are regular. Starburst dendrimers remain in a globular configuration for all generations above 4.

Though the initial research of starburst dendrimers focused primarily on biological applications, scientist have begun to examine their potential in the fields of materials science. Because of the spherical geometrical composition of starburst dendrimers, they can be arranged in a more orderly manner than the linear molecules currently used in conducting composites.[7,8] An organized configuration of the molecules used in electrically conducting materials would improve the performance and accuracy of specific devices.

Recently research has focused on the conducting properties of star polymers.[9,10] The star polymers being examined are not starburst dendrimers, but are somewhat similar structurally. The polymers studied are branched molecules, but have linear arms attached to a dendrimer core. (Fig. 2) These star polymers show great potential in the field of electrically conducting materials because they are more compact than linear polymers. Researchers believe that the conductive capabilities of the star polymers could be improved by the addition of an increased number of arms that are more uniform.[9]

Fig. 2. Electrically Conducting Star Polymer. Arms connected to dendrimer core (three benzene rings) are not uniform.

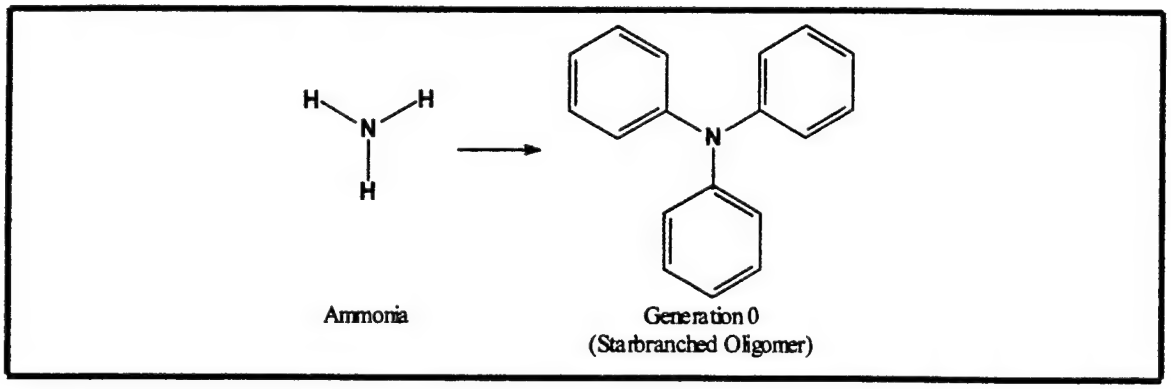


The development of a starburst dendrimer with the ability to conduct electricity would fit the criteria these researcher wish to improve upon. The radially symmetrical shape from uniform branches is more condensed than the diverse arms of the star polymers. The dense property of starburst dendrimers would also improve the surface morphology of films made from it. [9] Current examples of electrically conducting dendrimers rely on peripherally modifying the terminal repeating units by adding a chemical group with a slightly positive charge. [8,11]

Methodology

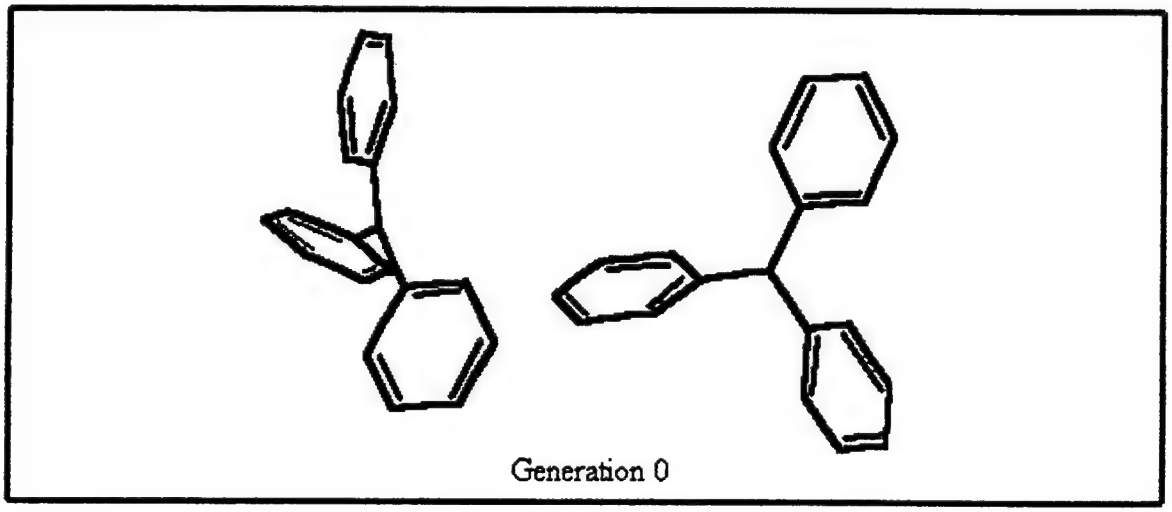
The preliminary structural design of the nitrogen-benzene starburst dendrimer was accomplished utilizing, HyperChem® (Autodesk) for arrangement and molecular modeling. An ammonia molecule was used as the initiator core because it has an initiator-core multiplicity of three (it can form three bonds). Ammonia or Ethylenediamine are the most commonly core molecules employed during dendrimer synthesis.[2,3] In order to create the starbranch oligomer, or Generation 0 of the dendrimer series, each hydrogen bonded to the central nitrogen atom was replaced with a benzene ring. (Fig. 3)

Fig. 3. Ammonia is used as the initiator core. The hydrogen atoms are replaced with benzene rings to for generation 0 of the dendrimer series. (Hydrogen atoms are not shown on benzene rings.)



After the completion of a generation, Molecular Mechanics optimization was performed on the molecule to minimize the energy of the system. By altering the molecular geometry (bond lengths, bond angles, torsion angles, and other atomic interactions), the potential energy of the system is lowered, rendering a more stable structural configuration of the molecule. Before geometry optimization was initiated, the molecule appears to be planar. However, after the finalization of the minimization, the composite can be viewed in its actual three-dimensional configuration. (Fig. 4)

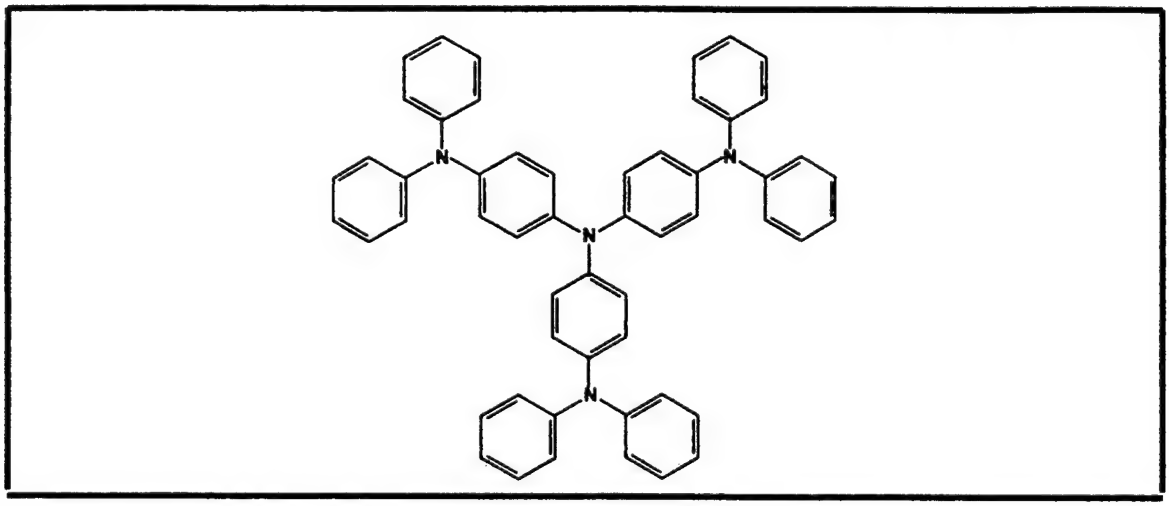
Fig. 4. View of Generation 0 after optimization. (Hydrogen atoms are not shown on benzene rings.)



To set up generation 1in this series of dendrimers, the hydrogen atom bonded to the carbon-4 in each benzene ring (para the original nitrogen) was replaced with a nitrogen atom. Six additional benzene

rings were generated and two bond with each secondary nitrogen. This produced the generation 1 dendrimer consisting of 100 atoms (4 nitrogen, 54 carbon, and 42 hydrogen). (Fig. 5)

Fig 5. Generation 1 before optimization. There are six peripheral benzene rings. (Hydrogen atoms are not shown on benzene rings.)



After molecular mechanics was concluded, each following generation was generated in a similar fashion. The hydrogen atoms bonded to the carbon-4 in each perimeter benzene ring were substituted with a nitrogen atom. Two additional benzene rings were then generated for each new nitrogen. Producing a starburst-dendritic macromolecule with all available bonding sites filled.

Results

This research project was concluded after the formation of the generation 6 dendrimer, compromised of 4192 atoms. Including the initiator core, the macromolecule contained 190 nitorgen atoms and 381 benzene rings, of which 192 were in the outermost boundary. The computer program used could not geometrically optimize an higher generation because of the vast proportions of the molecule.

After geometric optimization was completed, the conformation of the dendrimers coincided with previous results.[3-6] In early generations, the dendrimer appeared disk-like, even after geometry optimization (Fig. 6). In the ensuing generations, the optimized structure of the polymer emerged as a sphere (Fig. 7).

Fig. 6. Generation 3 after geometrical optimization. The arrangement of atoms is comparable to a disk, not a sphere. X-axis and Z-axis schemes shown. (Hydrogen atoms are not shown on benzene rings.)

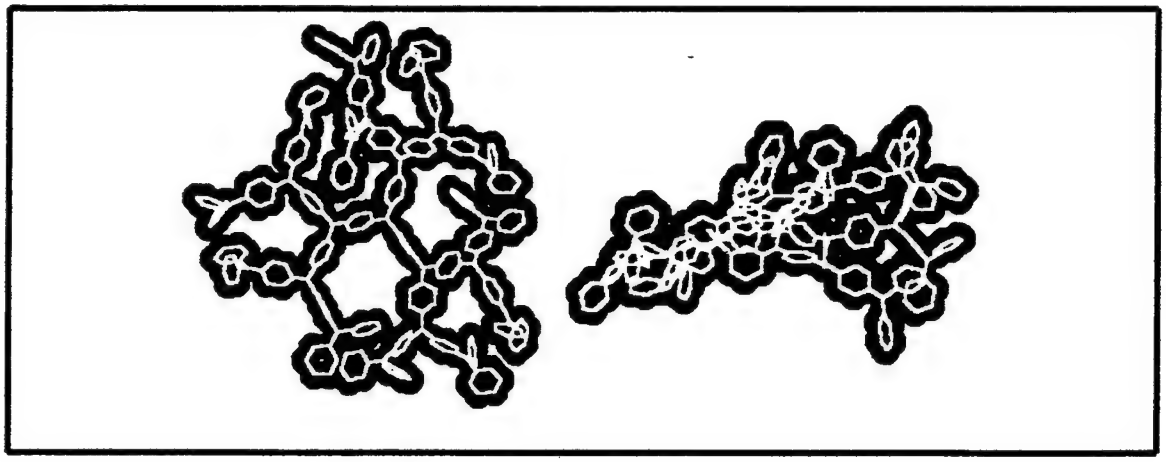
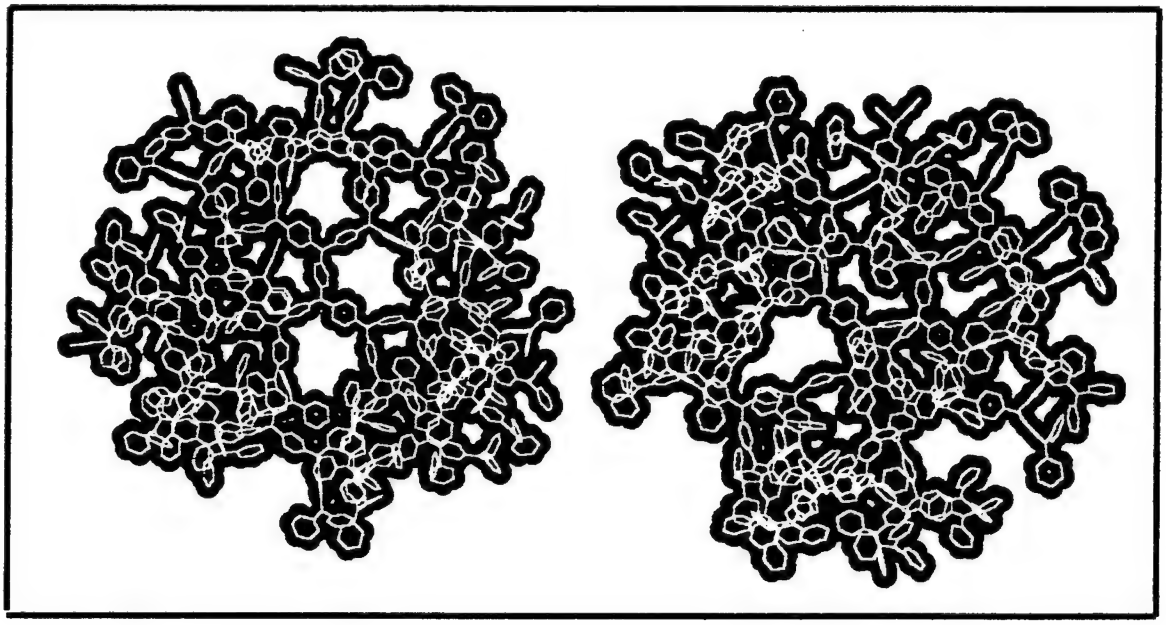


Fig. 7. Generation 5 after molecular mechanics was performed. The structure resembles a sphere. X-axis and Z-axis schemes shown. (Hydrogen atoms are not shown on benzene rings.)



Conclusion

The development of new materials is essential to the advancement of materials science. Reliable conducting dendrimers show promise in the field of science and technology because of their distinct characteristics. Their dense spherical arrangement is an improvement compared to the linear polymer

composites currently in practice. Future research must be completed in order to determine the potential conducting ability of this hypothetical nitrogen-benzene dendrimer.

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COMPARISON OF OBJECTIVE ASSESSMENT OF DIGITAL INFRARED IMAGE SEQUENCES

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COMPARISON OF OBJECTIVE AND SUBJECTIVE ASSESSMENT OF DIGITAL INFRARED IMAGE SEQUENCES

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Abstract

Objective and subjective quality assessment of digital infrared image sequences is compared. In order to do this one must choose sequences of infrared images to evaluate as well as a variety of methods for the computer to determine image quality. Then the computer and the observers can start ranking the images. In the end, we can compare and correlate theresults.

The correlation coefficients between pairs of observers show how similarly people rank the same image sequence. The correlation coefficients from the subjective and objective results show how closely objective assessments match subjective assessments.

Introduction and Problem

When dealing with digital infrared image sequences, the quality of the images vary. Some of these images are good quality images, while others contain erratic noise. Since it is desirable for all the images to be good quality, the bad images should be removed or enhanced. The image frames that contain erratic noise can be identified by assessing the image quality of a sequence of images.

Subjective assessment of image quality can be long, tedious, and expensive. It therefore makes sense to have a computer automate this task. Since we want the computer to assess image quality as well as the human visual system, the problem is to determine which method of objective assessment is the most similar to the subjective assessment. This is done by comparing the objective assessment with the subjective assessment.

Methodology

The first step is to choose sequences of infrared images to evaluate. This is done by viewing a survey of images. Image sequences with many images having high erratic noise content are chosen along with sequences that had little noise.

The next step is to find a variety of methods for the computer to determine image quality. Convert these objective assessments into computer programs or codes. Then run the codes on the image sequences. The three methods we used were spatial, temporal, and velocital metrics. They give us ratings of the image quality on different scales. We convert these ratings into rankings.

Meanwhile the observers can start ranking the images. The images in each sequence are ranked in order from best to worst based on erratic noise content. Each observer is told to look for black or possibly white dots or black lines going left to right or up and down on the screen. They are also told not to attempt to count the dots, just to make a judgment based only on what they see.

When the observers are finished ranking the images normally, the observers then rank the images methodically using sort algorithms. We chose for the observers to rank the images using the bubble sort, the binary insertion sort, and the heap sort. The sort algorithms are chosen based on being the simplest and having the least number of comparisons.

Lastly, when everything is done, we can compare and correlate the results. This is done by pairing up the data sets we want to compare and measuring the correlation coefficients between them. For example, we compare subjective and objective results for each image sequence. We also compare each

objective method's result with the other objective results, and we do the same for each observer's results. We can also visually look at the rankings to see patterns.

Results

We measured the correlation coefficients between pairs of observers. These results show how similarly people rank the same image sequence. When frames had low noise, the observers had difficulty ranking the image frames which led to low correlation between pairs of observers. This is due to the fact that subjective observers had difficulty ranking image frames that were similar. When frames had higher noise content, the observers were able to assess the frames more easily, and the correlation between pairs of observers was high.

Then we measured the correlation coefficients from the subjective and objective results. Because low amounts of noise resulted in low correlation coefficients between the subjective observers, the correlation coefficients between the subjective and objective results are not expected to be high. When we look at the results, the sequences with low noise had low correlation coefficients, and the frames with high noise had higher correlation coefficients.

We also noticed that, from our limited observations, the method of sorting done by the observer does not seem to have a significant effect on the precision of the results. The correlation coefficients were comparable with and without using the sort algorithms. It does force the observer, however, to be more methodical in ranking the images.

Conclusion

Of the frame-based objective metrics used in this research, the velocital metric appears to be more responsive to the sudden changes that are evidenced by erratic noise. It has proportionally higher peaks for the noisy imagery than the temporal information metric. Although, the spatial information metric appeared to have reasonable correlation with the subjective assessment, it occasionally misranked frames that were obviously extremely poor in quality.

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IMAGE ANALYSIS OF POLYMER DISPERSED LIQUID CRYSTALS

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Final Report for:
High School Apprenticeship Program
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And

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August 1998

IMAGE ANALYSIS OF POLYMER DISPERSED LIQUID CRYSTALS

Daniel Cleyrat

Abstract

I was presented with the task of writing specialized macros for Optimas, an image analysis software package. Images of polymer dispersed liquid crystals (PDLCs) needed to be analyzed to measure certain aspects of the liquid crystal regions such as size, diameter and length along the x and y axes. This all needed to be automated so that anyone could come in and pick up the manual and analyze an image in a small amount of time. Because Optimas has such a rich macro language it was an ideal program to use.

IMAGE ANALYSIS OF POLYMER DISPERSED LIQUID CRYSTALS

Daniel Cleyrat

Introduction

Optimas was the ideal choice for image analysis as it is very flexible. It's macro language is heavily based on the popular C language, making it very simple for veteran C programmers to use, and easy enough for novice programmers to use. The software includes an extensive manual, and an online manual for easy reference. Using this program, I had to create a macro so that people could come in, load it up, and have a simple way of analyzing an image, without having to learn the entire Optimas program.

Discussion of Problem

Some of the Problems faced were decisions on how to measure objects in the images. For one, there were two ways of measuring X and Y lengths of areas. One involved fitting an ellipse to the object and then calculating a major and minor axis based on it. Another choice was to fit a rectangle parallel to the axes around it and measure the X and Y length of the box to get the values for the object. We decided with the latter as it was more useful in finding the anisotropy of objects. Another problem faced was in the actual coding. At first the program was written with nested if statements, which means an if-then function kept calling on itself and buried itself into a crash. This was a bad idea, although there were no known alternatives to writing the code. After some thorough digging into the manuals it was discovered a pointing type statement could loop it without burying itself.

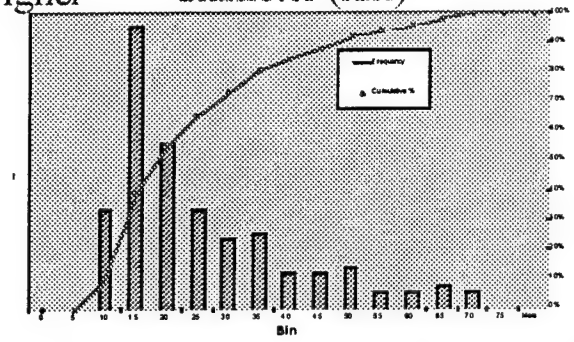
Methodology

The method of writing a useful program, or macro in this case is usually gone about in the same way. The programmer much create some kind of an interface for the user to use to provide input for the computer. Then the programmer must tell the computer to process the information and present it back to the user in a meaningful and useful way. To do this I had the Optimas macro ask the user to set such things as unit measurement, the region of the image to analyze and minimum diameter size. After that, I had the program ask the user whether or not to use 6 operations which involved area creation. In the case of grating images, there was a second macro, which differed in that it asked whether or not to measure another grating channel. Then the data is written as a Microsoft Excel file. With Excel then, I wrote a visual basic macro to organize the data, perform a few more calculations and create a histogram of a chosen field of data.

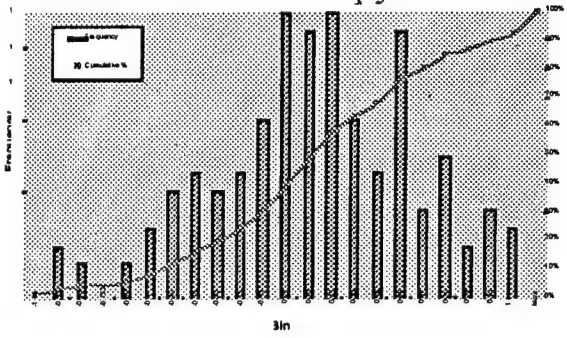
Results

The result ended up with three good macros which are flexible enough to allow for some modifying if new types of problems arise. The macros provide step by step instructions on what to do next and suggestions as what to expect. The macros are also commented inside so that if future programmers come in to work on it, they will have a better understanding on what has been written. Presented here is some data from PDLCs that have been analyzed with this software. As you can see in the histograms below, several conclusions can be made from the data. The data is of diameter sizes and an adjusted X versus Y scale.

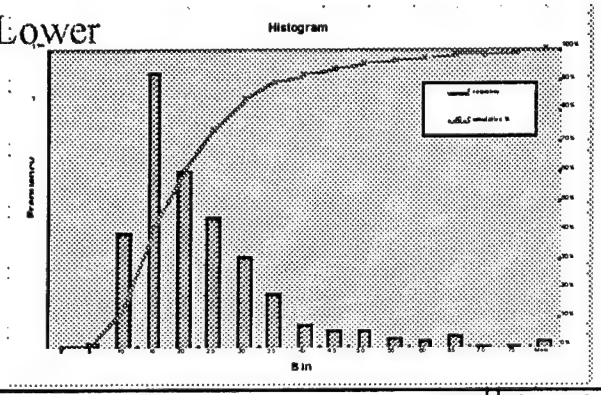
Higher diameter (nm)

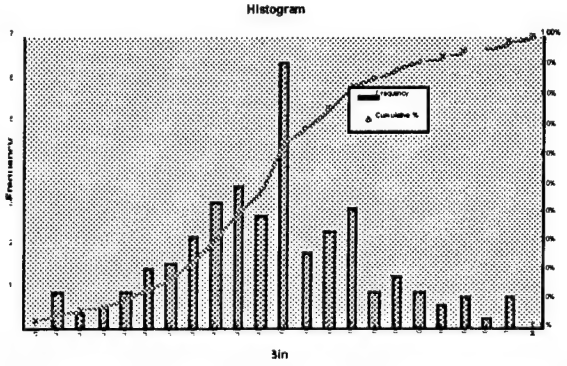


anisotropy

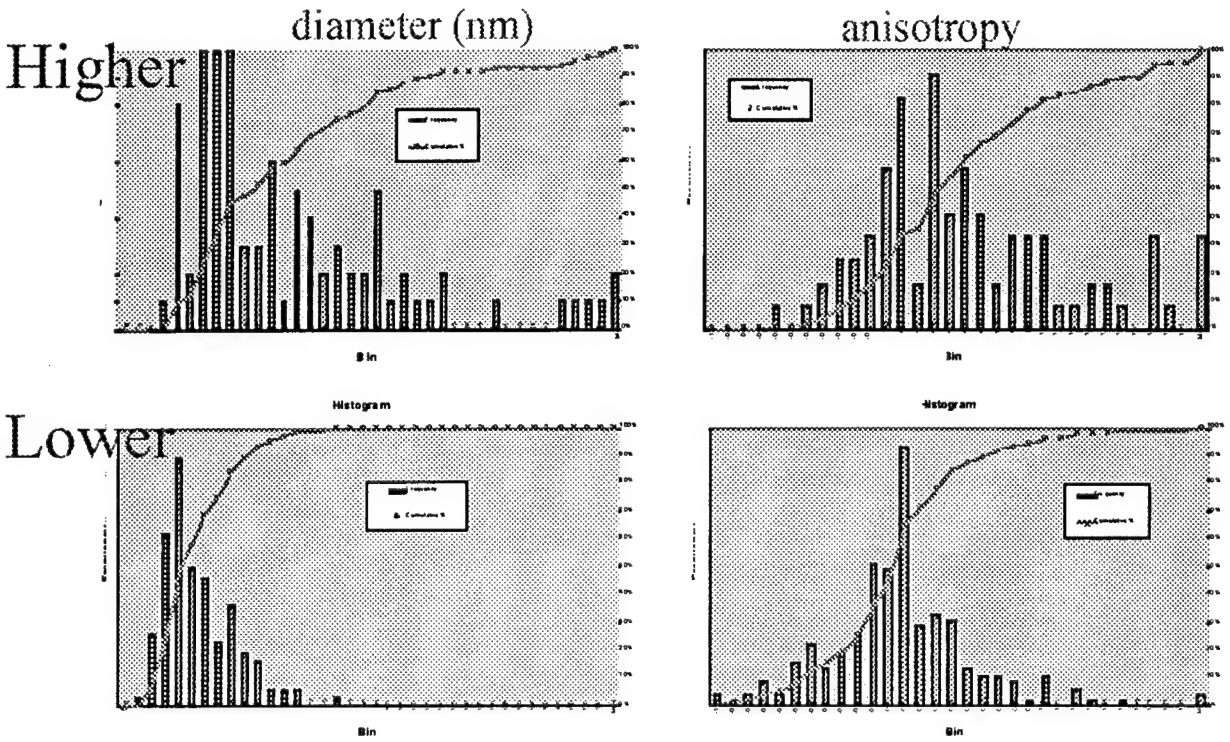


Lower





- small sizes
- anistropy related to volume fraction
- volume fract. differences



vol. frac.decreases as funct. decreases - weaker driver
small domains - smaller as funct. decreases
more spread in domain size for higher funct.
larger anisotropy for higher funct.

Conclusion

Optimas and its macro language provide a very rich environment for image analysis. The macro I created provided a simple way to collect data on properties such as area, perimeter, diameter, etc. Although the macro only deals with two types of PDLC images, it could be easily expanded to provide analysis on several types of images. Paired with Excel or another graphing program, it becomes an extremely helpful tool.

Included below is the Optimas and Excel Macro Manual written with step by step instructions. It is written in mind of people with very little, or no computer experience.

Macro Pieces:

Dans folder and all items in it, need to be in C:\Optimas6

ArCustomX.mac needs to be in the C:\Optimas6\Macros directory

Dans BackUP In case you accidentally, erase, alter, etc.. the original macro, there is a backup in the C:\Optimas6 directory. Make sure you make a backup of the backup in case of a screw up. Should be renamed Dans if you do need to use it.

Custom Stuff Manual More info on macro writing and excel macros, histograms etc.

First thing you need to do is turn on the computer by pressing in the power button. After windows has booted you need to login with your login name and password. A black box with warnings should come up, click inside it and press the space bar. When you get a 2nd login box you can just hit escape. To launch Optimas click the Start button on the Start Menu and go to Programs -> Optimas6.2 -> Optimas6.2. Once it has loaded you will need to choose an image to analyze. Go to File-> Open Image File. To find an image on the network you need to click on the arrow ⇓ tab and select Network Neighborhood. This will give you a list of servers. In the case of Tim, go to ML-651 -> users -> bunnintj. After choosing an image you need to open the appropriate macro. For Floodlit images use Floodlit.mac and for Gratings use Grating.mac. Both of them are located in C:\Optimas6\dans. To open them, in Optimas click the Macro menu and click open. This should display the contents of the Optimas directory. Open Dans and you should see the 2 macros as well as other things. Open the appropriate macro. If it does not begin you in the Optimas directory you need to click on the arrow ⇓ tab and go to the C: drive, then open up the Optimas directory, then you should see the Dans directory.

Pre-macro stuff

Control

When drawing and such, USUALLY left click draws and right click finishes.

Anytime you are prompted with a yes/no type box you have control to adjust the ROI with the green tools (The ROI finishes with a left click, one of the exceptions to above), autocreate areas and do other tasks. Be warned, the autocreate tool on the bar is not the same as the one in the macro. This applies to zooming as well, so you can change before say, point and click area making.

Zooming

To zoom or unzoom, right click on an image, go to zoom, and select a magnification. For regular use, 50% is good. When drawing areas, 100% is good.

Canceling

Pressing Escape will terminate the running macro.

Getting it out of the way

You probably want the macro box out of the way, so resize it by holding the mouse over the border until you get an arrow and shrink it, you can also drag it by the blue border. You still need to be able to see the menu items on the window.

Filtering

Sometimes there is noise in the image or unwanted tendrils and its a good idea to smooth it out. To filter go to the Image menu and select Filters. The Average and Median filters are good to use. For little noise use 3x3 for more noise use 5x5.

Contrast

Although changing the contrast will not truly effect the image, it may make it easier for yourself to identify things. To change the Contrast go to the Image Menu -> Output Luts -> Intensity map. To change the contrast use the arrow keys in the bottom center. To apply special functions press the ⇓ tab and select one. For Gamma and Posterize you will need to set a value in a small box above the ⇓. When you have selected one, press apply.

IMPORTANT

The image must be in black & white. Also, for Tim's create to work it must be 8-bit. To convert it, go to the Image menu, go to Convert To, and select 8-bit gray.

Floodlit.mac instructions

Start by pressing Run! on the macro menu. A box will appear, prompting you to calibrate units. Press OK. Now press the Add/Edit button. Name the new calibration if you wish (it may not contain numbers). Click on the ⇓ tab and select the units that the image is in. Then press the calibrate button and draw a line over the dotted line. Left-Click once on the left of the line move it over to the rightmost of the line and left click again, then right click. When it asks you for how long it is, tell it that number in units down there. (note: If it is say, 1.2um it is a better idea to use nanometers and after calibrating tell it that its 1200nm). After calibrating press OK. Then press OK again. Then you need to select the new calibration you need and press Switch (it will usually be named Calibration3 or Calibration2 if you have not renamed it). After that close the window with the X or minimize it with _ whichever you want. Then Press Continue! on the macro menu.

Now it prompts you to choose a ROI with the Green tools. The ROI is the area you wish to analyze. The square box draws a square ROI and the squiggly one draws a freehand ROI. The circle is rather useless and the gray-green one sets it to full screen. Press Continue! from the macro's menu to continue.

Next it asks you to set the minimum diameter. Autocreate will be based on this so that you don't end up with a lot of garbage. When you free hand or use Tim's point and click it does not discern. You may want to check your image with a ruler and see how small the eye can see one or you can take the suggestions from the box. I would set it no less than 4 no matter what, but its up to you. For 25x files it usually 4, for 50x files its 8 for 100x its 16, see the trend... Use common sense, and think about the image width when you set the calibration.

Now it asks you to set a filename for it. Make sure you keep the .XLS extension so that its easy to open with excel. Just remember where you put it, or you'll have to end up searching for it.

Now you're in the master loop. This consists of 6 parts. After asking you to use the 6, it will give you a volume fraction and ask you if everything is OK. If it is not and you press NO, it will bring you back to the 6 questions.

Threshold -(Sets the foreground for what autocreate bases its area creating on)

This sets the foreground by which autocreate bases its areas on. the top value should be 0 and the 2nd value is up to you. 0 is black 255 is white. In between is gray. It's a good idead to flip the Hide Lut box on and off to see if you get the threshold good. When you're done with that box press OK.

Auto-create Areas -(Automatically creates areas based on the threshold)

This makes areas based on the Threshold you set. The minimum size by measure of diameter you set will exclude the smaller areas that are probably garbage. If you come back for a second time and choose to Auto-create, it will destroy previously made areas and build new ones. If you have large areas that are touching and have turned into one area, it's probably a good idea to skip freehand and delete and go ahead and run separate. If after autocreate there are a lot of touching areas you may want to run separate (see below).

Freehand -(Lets you draw areas with the mouse)

This is somewhat tedious but a last line to make areas. When you create areas you use the left mouse button to draw, when you're done press the right mouse button and it will ask you if you'd like to make another. It is better to come back to this after using Tim's create as it is a real pain.

Delete -(Pick and choose areas to delete with the mouse)

This lets you pick and choose areas to get rid of. To delete triple left click an area. When you're finished press the right mouse button.

Separate -(Separates touching areas)

If you're going to do any separation you should do it 1st and then loop back to other task. Separate will destroy any previously made areas. It also asks you threshold again. When it recreates the minimum diameter limiter is taken into account. Be warned, Separate may break things up too much and its usually not a good idea to use it unless you have a lot of larger areas. If Separate yields bad results just go back and do an auto-create. Separation Breaks apart areas by eroding them and then building them back up and creating areas, then reverting the picture back to normal. It's good for breaking up larger areas that touch by a thread.

Tim's wonderful point and click -(Point an area the surround it in a box, makes an area, easier than freehand)

Probably the most useful thing. *If you do this wrong you can screw up everything you've done so far.* Make sure you have set a threshold at one time or another before doing this. This lets you click a mere point on an area and draw a box around it to make an area. This will give you an arrow with a P on it. Left click once to choose a point then right click. Then it gives you another Arrow this time with an R on it, draw a box around the area by left clicking once, dragging the box and left-clicking to finish, as close as possible it doesn't have to be perfect as long as its not overlapping other areas and things. What this does exactly is take the luminescence value of the point and adds 30 to it and autocreates an area based on it.

At the end of the loop it gives you a volume fraction and asks if everything is ok. If you say no, it takes you back though the loop and asks if you want to do any of them again. If you choose Yes, it extracts the measurements, writes it to the file you specified and closes up. Now you need to go to Excel.

Grating.mac Instructions

Grating starts just like Floodlit

Start by pressing Run! on the macro menu. A box will appear, promting you to calibrate units. Press OK. Now press the Add/Edit button. Name the new calibration if you wish (it may not contain numbers). Click on the ⇓ tab and select the units that the image is in. Then press the calibrate button and draw a line over the dotted line. Left-Click once on the left of the line move it over to the rightmost of the line and left click again, then right click. When it asks you for how long it is, tell it that number in units down there. (note: If it is say, 1.2um it is a better idea to use nanometers and after calibrating tell it that its 1200nm). After calibrating press OK. Then you need to select the new calibration you need and press Switch (it will usually be named Calibration3 or Calibration2 if you

have not renamed it). After that close the window with the X or minimize it with _ whichever you want. Then Press Continue! on the macro menu.

Next it asks you to set the minimum diameter. Autocreate will be based on this so that you don't end up with a lot of garbage. When you free hand or use Tim's point and click it does not discern. You may want to check your image with a ruler and see how small the eye can see one or you can take the suggestions from the box. I would set it no less than 4 no matter what, but its up to you. For 25x files it usually 4, for 50x files its 8 for 100x its 16, see the trend... Use common sense, and think about the image width when you set the calibration.

Now it prompts you to choose a channel using the ROI with the Green tools. The ROI is the area you wish to analyze. The square box draws a square ROI and the squiggly one draws a freehand ROI. The circle is rather useless and the gray-green one sets it to full screen. Make sure you make it as tight as possible, as you could throw off the volume fraction of the channel. Press Continue! on the macros menu to continue.

Now it asks you to set a filename for it. Make sure you keep the .XLS extension so that its easy to open with excel. Just remember where you put it, or you'll have to end up searching for it.

Now you're in the master loop. This consists of 6 parts. After asking you to use the 6, it will give you a volume fraction and the width of the channel and ask you if everything is OK. If it is not and you press NO, it will bring you back to the 6 questions.

Threshold -(Sets the foreground for what autocreate bases its area creating on)

This sets the foreground by which autocreate bases its areas on. the top value should be 0 and the 2nd value is up to you. 0 is black 255 is white. In between is gray. It's a good idead to flip the Hide Lut box on and off to see if you get the threshold good. You probably want to be darker and over shoot it when you're dealing with gratings. When you're done with that box press OK.

Auto-create Areas -(Automatically creates areas based on the threshold)

This makes areas based on the Threshold you set. The minimum size by measure of diameter you set will exclude the smaller areas that are probably garbage. If you come back for a second time and choose to Auto-create, it will destroy previously made areas and build new ones. If you have large areas that are touching and have turned into one area, it's probably a good idea to skip freehand and delete and go ahead and run separate. If after autocreate there are a lot of touching areas you may want to run separate (see below).

Freehand -(Lets you draw areas with the mouse)

This is somewhat tedious but a last line to make areas. When you create areas you use the left mouse button to draw, when you're done press the right mouse button and it will ask you if you'd like to make another. It is better to come back to this after using Tim's create as it is a real pain.

Delete -(Pick and choose areas to delete with the mouse)

This lets you pick and choose areas to get rid of. To delete triple left click an area. When you're finished press the right mouse button.

Separate -(Separates touching areas)

If you're going to do any separation you should do it 1st and then loop back to other task. Separate will destroy any previously made areas. It also asks you threshold again. When it recreates the minimum diameter limiter is taken into account. Be warned, Separate may break things up too much and its usually not a good idea to use it unless you have a lot of larger areas. If Separate yields bad results just go back and do an auto-create. Sepatation Breaks apart areas by eroding them and then building them back up and creating areas, then reverting the picture back to normal. It's good for breaking up larger areas that touch by a thread.

Tim's wonderful point and click -(Point an area the surround it in a box, makes an area, easier than freehand)

Probably the most useful thing. . *If you do this wrong you can screw up everything you've done so far.* Make sure you have set a threshold at one time or another before doing this. This lets you click a mere point on an area and draw a box around it to make an area. This will give you an arrow with a P on it. This means to pick a point on an area. Right click after clicking on an area ONCE. Then it gives you another Arrow this time with an R on it, draw a box around the area, as close as possible it doesn't have to be perfect as long as its not overlapping other areas and things. What this does exactly is take the luminescence value of the point and adds 30 to it and autocreates an area based on it.

At the end it gives you a volume fraction and the width of the channel. Then it asks if everything is OK, if it is, click OK, else say no and go through the loop again.

After extracting the measurements it asks you if you want to measure another. If you say yes you get to choose another channel and go though the loop for it. If not and you're done it writes the file and closes out

EXCEL

Now that the data's collected I'm sure you want some charts and stuff. So open up Excel by Pressing Start on the Start Menu going to Programs and to Microsoft Excel. Then you need to open up the macro file. This is in the same place as the Floodlit and Grating macros. To get there go to File-> open. Click the Icon with the ⇑ on it and then go into Optimas6 and then to Dans. There should be a file called macrofile.xls there. Open it. Then minimize it by pressing the _ box. Next open up One of your data files. It's your problem where you put it.

Column Meanings

mArArea: Area Measurement

mArPerimeter: Perimeter measurement

mArC_xlength: length of X axis of object

mArC_ylength: length of Y axis of object

mArC_XoverY: xlength divided by ylength

mArAreaEquivDiameter: Diameter based on mArArea using pi r squared…

---Created after running 1st macro

X>Y: Used for adjusted histogram

Y>X: Used for adjusted histogram

Combined XvY: The X>Y and Y>X columns decide which of the 2 measurements is greater then does an equalizing equation on them so the histogram will center at 0. The problem was the scale. If X=2 and Y = 1 x/y is 2 and vice versa its _ so when centering around 1, the scale was not accurate.

In the header under each of the measurements there is a count, mean, standard deviation etc.

Macro

Now you need to make sure your data file is the frontmost window and go to the Tools menu and to Macro… There should be 3 macros. ChartCompare, RunMe1st and RunMe2nd.

RunMe1st

Like the name, you need to run this one 1st. This will begin formatting the existing page, and adding new columns of calculations. It will ask you for a Column NUMBER to histogram. This will create a Histogram with a weird bin excel decides. Its good to look at to get an idea of how you will want to bin your data. You should notice a Data and a Histogram Tab down at the bottom of the page. Data is your 1st sheet with the Data, Histogram contains the weird histogram excel made. You don't want to run this macro again on the same data file.

RunMe2nd

Now you get a chance for some control. Open the macro by going to Tools-> macros... and opening RunMe2nd. This will start by asking you what you want to name your sheet. Give it a name and hit return. Then it will ask you what column. Type in a column NUMBER and hit Ok. Then it will ask you for a minimum bin value. In the case of diameters and such it's usually 0. For XvY stuff it should be something around -2. Then it asks you for a Step Value. Step would be if you wanted to bin say 0, 5, 10, 15, 20 the step is 5. Then it asks for a maximum bin value. This is of course is what value to stop at. For XvY I would recommend something around 2. Then its done. You can resize the chart or run the macro again if you want.

ChartCompare

This compares two columns of data from the same data file asking you bin values and names and such. It will not work except from data from the same sheet.

DualChart

This works when you put 2 columns of data side by side only. You have to copy and paste say a Diameter column and put it in a column parallel to the 2nd diameter column like this:

Diameter1	XvY	Diameter2
2	6	3
6	9	5
1	8	7

DO NOT PUT ANYTHING IN COLUMN L

THEY MUST BE LINED UP LIKE THIS, but not necessarily side by side

Then you run the macro and name a new sheet etc. and give it the column numbers.

When you're done

To save, go to the File menu -> save as... Here you need hit the 2nd dropdown box ⇓ and select Microsoft Excel Workbook (xls). and save it somewhere. Printing is done thought the File ->Print... dialog.

Troubleshooting Excel

If you cant get your file to open.

> You probably forgot to put the .xls extension on it. To add the extension, find the file, right click on the file and rename it with the .xls extension.

Gives blah blah error in formula.

> You probably entered an invalid response in one of the Prompt boxes. rerun it and be more careful.

TENSILE PROPERTIES OF ALIGNED CHOPPED-FIBER CARBON FIBER REINFORCED POLYMERIC COMPOSITES

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And

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August 1998

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Amanda J. Colleary

ABSTRACT

The tensile properties of polymeric composites reinforced with aligned, chopped carbon fiber tows were measured and compared to corresponding composites reinforced with continuous fibers. Panels were created using uni-directional tape and making small incision according to a defined template IM7/977-3 and AS4/APC2 were the two materials used in the study. Specimens were cut from each panel and tested to failure to determine tensile strength and modulus. Significant differences were shown in strength and modulus between the two material systems. Another factor was the fiber alignment - a 0° panel outperformed a ± 5° panel in modulus, and contrary to what we had hypothesized, the ± 5° panel had the greater tensile strength. These experimental results are below the 80% strength translation goal expected based on data from other researchers, but meet or exceed the 90% modulus translation goal.

TENSILE PROPERTIES OF ALIGNED CHOPPED-FIBER CARBON FIBER REINFORCED POLYMERIC COMPOSITES

Amanda J. Colleary

Introduction

The Programmable Powdered Preform Process (P-4) is used to make fiberglass preforms for automotive composite structures. It uses a computer controlled robot that cuts fiber tows, and can vary fiber length and lay-up angle within the machine, presenting the potential for extreme adaptability in design and fabrication at a reduced cost. Using carbon fibers, the P-4A (aerospace) also has a robot that sprays chopped tows onto a perforates screen at a variable rate. The current mission of the program is to determine whether chopped fiber composites created using the P-4A process are feasible for use in an aerospace environment.

Discussion of Problem

To determine the feasibility of the P-4A program, comparisons between metal, continuous fiber composites, and chopped fiber composites need to be conducted. Extensive research on metal versus continuous fiber composites has been completed, however the amount of data available regarding the translation of properties between continuous and chopped fiber composites is very small. Chopped fiber composites are generally weaker than continuous fiber composites.

Methodology

Laminate panels were constructed by hand lay-up using uni-directional tape to obtain perfect fiber alignment. Three nine inch by six inch, eight-ply panels were constructed with each material.

Panel	Material	Stacking	Tow Length
1	IM7/977-3	$[0]_8$	Continuous
2	IM7/977-3	$[0]_8$	4.5" Tow
3	IM7/977-3	$[+-5]_{2s}$	4.5" Tow
4	AS4/APC2	$[0]_8$	Continuous
5	AS4/APC2	$[0]_8$	4.5" Tow
6	AS4/APC2	$[+-5]_{2s}$	4.5" Tow

Table 1. Panel identification and properties. Note: 12K tows and zero tow overlaps were used in all panels.

Panels 1 and 4 were the baseline panels for each material system. Panels 2 and 5 modeled a chopped fiber with 0° alignment, and panels 3 and 6 simulated a ± 5° misalignment of fibers by the robot. The chopped fibers were created by using specific plies for each panel, (Figure 1) and offsetting overlapping plies to ensure that none of the tow ends

in different plies would coincide (Figure 2). The panels were autoclave cured using the standard cycle for each material.

After fabrication, the panels were tabbed and cut into test specimens. The control panels (1 and 4) were cut into one-half inch wide specimens with a six inch long gauge area, and the other panels were cut one inch wide. The one-inch width of the test panels was chosen to obtain a large number of tow fiber ends in one specimen (Figure 3). Tensile testing to failure was conducted with an attached axial extensometer. All failed specimens were retained for later analysis by the P-4A team.

Results

Specimen ID	Ultimate Strength (ksi)	Average Panel Strength (ksi)	Standard Deviation (Ksi)	Modulus (Msi)	Average Modulus (Msi)
1-1	324			24.46	
1-2	326			24.7	
1-3	349	333	11.2	no data	24.6
1-4	327			no data	
1-5	342			no data	
2-1	170			24.79	
2-2	170			24.84	
2-3	168	175	7.82	24.27	24.5
2-4	180			23.77	
2-5	186			24.79	
3-1	192			21.92	
3-2	180			no data	
3-3	199	192	7.22	22.98	22.7
3-4	196			22.23	
3-5	192			23.78	
4-1	216			no data	
4-2	293			no data	
4-3	264	259	28.1	no data	18.9
4-4	253			18.5	
4-5	269			19.38	
5-1	115			no data	
5-2	205			no data	
5-3	225	175	44.4	no data	19.2
5-4	182			19.4	
5-5	146			19.05	
6-1	119			no data	
6-2	217			no data	
6-3	228	181.6	53.3	no data	19
6-4	216			19.7	
6-5	128			17.3	

Table 2. Tensile strength/modulus for each specimen

As shown in Table 2, the strength and modulus properties of the discontinuous fibers are much less than the continuous fiber panels. All specimens exhibited intralaminar failure.

Generally, it is observed that specimens with misaligned fibers are much weaker than those with aligned fibers, especially when tested parallel to the fibers as in the 0° panels. In these tests, an unexpected result was that the misaligned chopped fibers (the ± 5° panels) seemed to be stronger than the chopped 0° panels. However, the 0° panels retained a higher modulus translation than the ± 5° panels.

The IM7/977-3 panels were much weaker and generally had a lower modulus than the AS4/APC2.

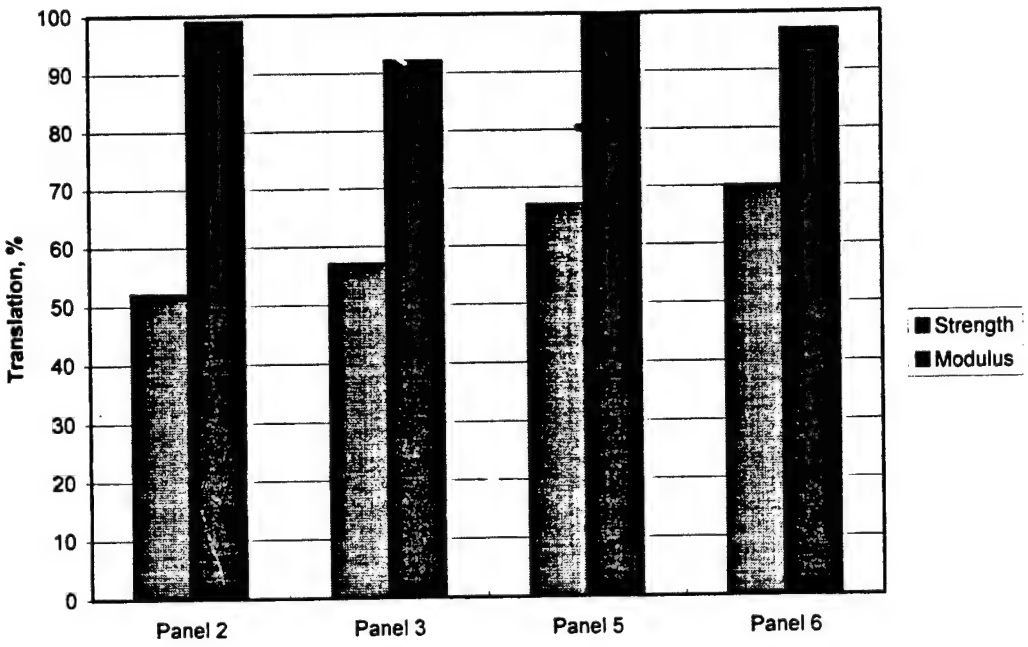


Table 3. Strength and modulus translation in chopped fiber composites.

Conclusions

There are many variables that have an effect on the ultimate strength and modulus of a chopped fiber composite. Experimental results indicate the following:

- The choice of a material/resin system has a major effect. AS4/APC2 yielded superior performance in all testing over IM7/977-3. Previous studies by the P-4A team support this conclusion as well.
- Tow misalignment seems to improve the tensile strength of the chopped fiber panels by 3% to 5%.
- Strength translation is below the goal of 80%; the modulus translation meets or exceeds the goal of 90% set by the P-4A team.

References

1. "Automotive Composite Process Technology for Aerospace - Technical Proposal In Response to PRDA No. 97-30-MLK"

2. Previously collected P-4A data

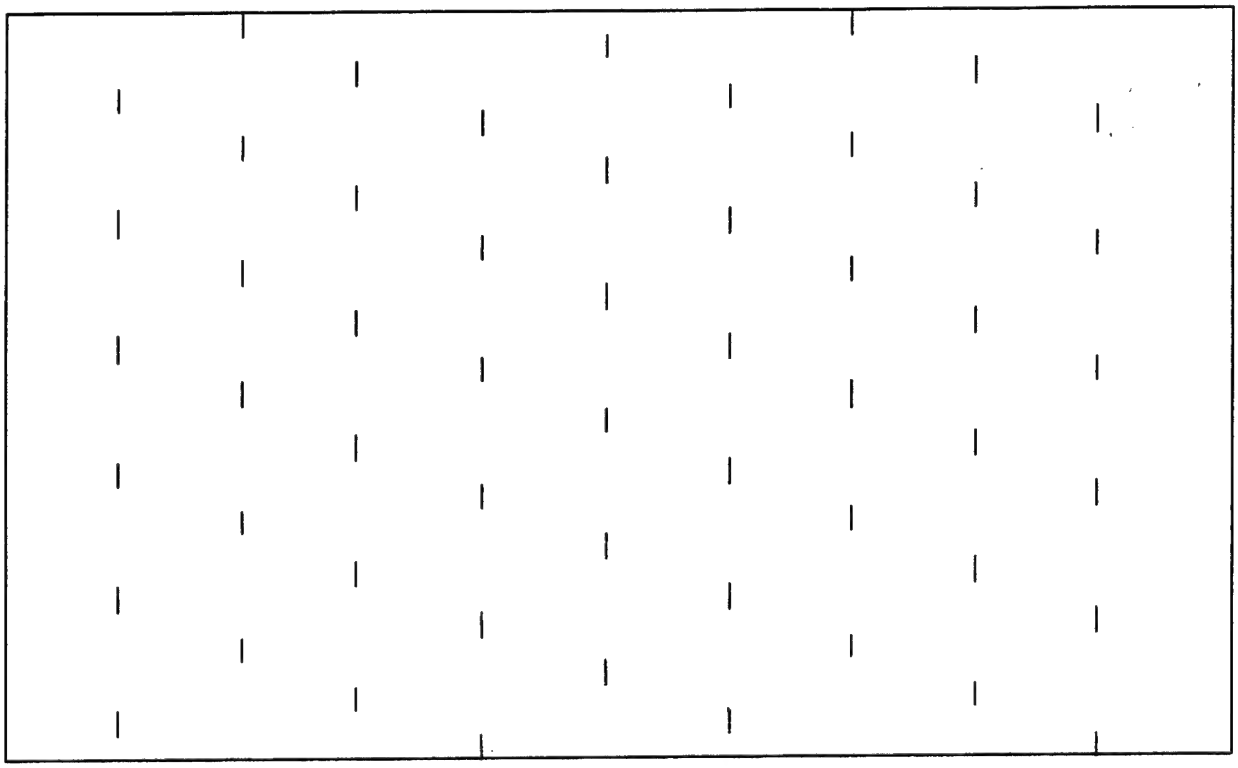


Figure 1 - Sample template for a single ply

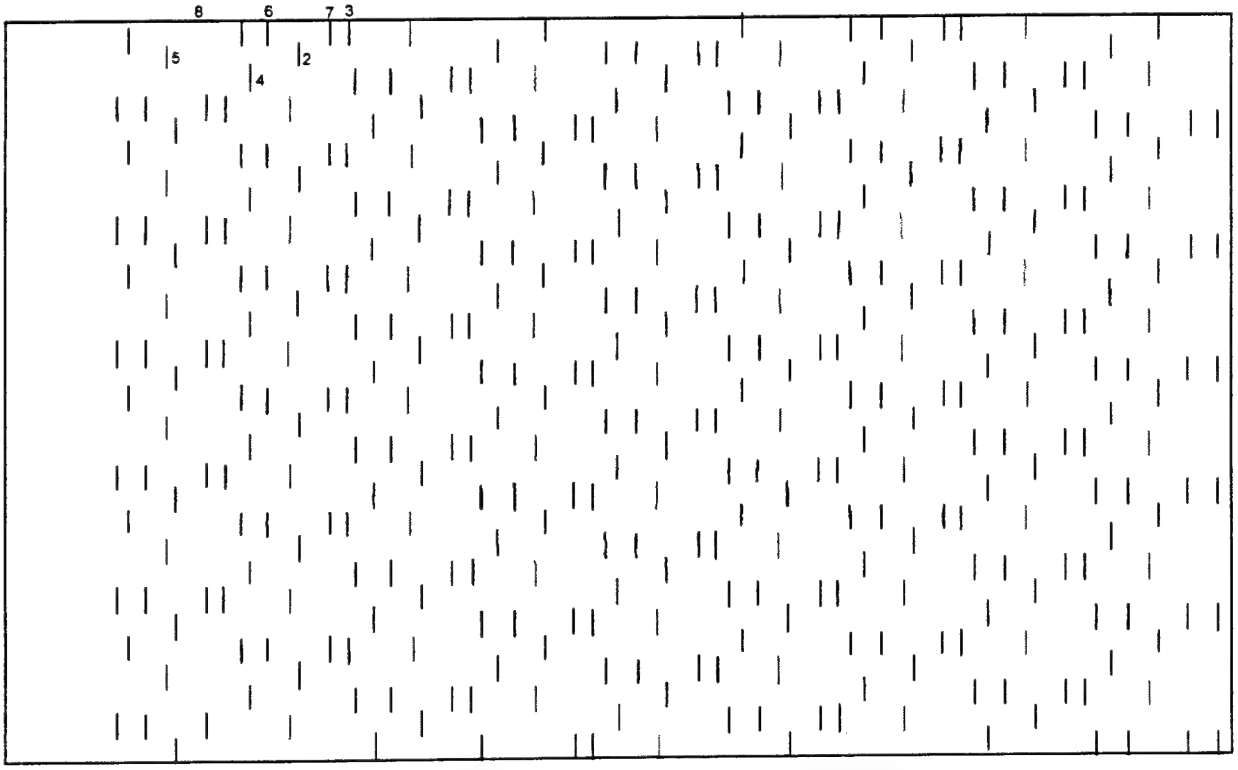
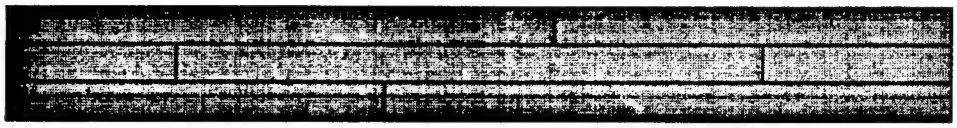


Figure 2 - Master overlay template for all eight plies



<- Fiber Direction and Load ->

Figure 3 - Sample test strip

A STUDY OF ACOUSTIC AND SONIC FATIGUE

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

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A STUDY OF ACOUSTIC AND SONIC FATIGUE

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Abstract

I studied the results of very high acoustic levels on the structure of airplanes, and I also studied sound waves. To generate high acoustic sound waves, the laboratory used an acoustic chamber where the structure would be put in the chamber. Experimental indicated that large structures (complete missiles) can be tested at continuous sound fields as high as 172 dB (1.2 psi of dynamic pressure), and the experiments also indicate that serious damage can be caused to structures, systems, and components due to the high level of noise. Sometimes the damage is so severe it can cause instantaneous failure in areas that cannot withstand high acoustic structures.

A STUDY OF ACOUSTIC AND SONIC FATIGUE

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Introduction

In recent years, testing structures for very high acoustic levels has been very important since airplanes have been able to reach higher speeds which increases the noise airplanes emit. In the acoustic test chamber, the coupons (test panels) are used to see how long they last under extreme sound pressure. I worked with Dr. Howard Wolfe with S-N curves. The S-N curves deal with how many cycles to failure to RMS (root-mean-square) stress usually measured in ksi. Dr. Wolfe would test multiple coupons of various styles and materials to check the strength of the coupons. His goal is to create a Sonic Fatigue Design Guide for Military Aircraft for design engineers to know the strength of structural materials under a certain range of pressure.

I also worked with Mr. Ralph Shimovetz on the Hartmann Noise Generator (See Figure 2). The purpose of the Hartmann Noise Generator is to provide higher acoustic power levels in the acoustic test chamber. Military Aircraft structures need to be tested at higher acoustic noise levels because of the powerful, loud jet engines. One way to structures under higher acoustic levels is to build a Hartmann Noise Generator. I helped Mr. Ralph Shimovetz with finding the dimensions and drawing sketches.

Dr. Jon Lee (my primary mentor) helped me understand sound waves and vibrations through many experiments. He also showed me the tools engineers used. The experiments I did with Dr. Lee used an accelerometer, Vibramatic exciter (shaker), oscilloscope, and FFT (Fast Fourier Transform) analyzer. Dr. Lee also taught me the mathematics behind FFT, and he taught me integration and differentiation since I have not learned it in school yet.

Methodology

Dr. Wolfe has gathered the S-N data from his experiments. Most of his experiments were carried out on a shaker. I received the data on a graph that usually has only the data points; sometimes it has graphs, curves drawn through the data points. I took four points from the data, and graphed them. After

fitting the four points with a straight line, I found the regression equation for best fit where K is constant and a the slope:

$$S = KN^{\alpha}$$

S is RMS Stress (ksi), N stands for cycles to failure, K a constant, and a the slope. After I determine the regression equation, I made it replicated the test.

Working with Mr. Shimovetz, I found the dimensions of the Hartmann Noise Generator. I used a document called "High Level High Frequency Noise Generation In The NAE Spacecraft Test Chamber" which has the dimensions of the resonant cavity, and there was a picture of the Noise Generator within the document. With dimensions of the Hartmann Noise Generator given in the document, I used proportions to find the actual measurements of the Hartmann Whistle.

With Dr. Lee I worked on many experiments that involved spring-mass. The first experiment I did with the springs was to find the spring constant of a given spring which is defined by:

$$f = (1/2\pi)\sqrt{k/m}$$

Where f stands for frequency, k is the spring constant, and m the mass. I hung a spring to the stand and attached a 500 gram mass attached to the other end. I would pull down the spring a little bit (about a half inch) because if you pull the spring down more it might show a nonlinear behavior, and that would not give me the correct spring constant. I used a stopwatch and my eyes for this experiment. I pulled down the mass a little bit. When I released it, I start the stopwatch. I count ten cycles and then I stop the stopwatch. Then I convert the measurement data into cycles per minute or second.

For the next experiment, I wanted to see when the spring-mass system goes into a nonlinear stage. I would then again suspend the spring with a 500 gram mass from the stand. I then placed additional one gram masses on the 500 gram mass in succession. I would record the spring extension results, and plot them.

Another experiment I did with Dr. Lee and the spring-mass system was to trace the displacement of vibrating mass. I was going to use a laser vibrometer for this experiment, but it was set up to the horizontal at present and not the vertical displacement. Instead I used a Kistler accelerometer with the sensitivity of one volt per G. The accelerometer gave me the time-history data. This data looked similar to

a sine wave, but it is not the displacement data because it showed me the acceleration. This is because acceleration is the second derivative of displacement.

The next experiment involved a shaker, the spring, the mass, an accelerometer, a FFT analyzer, and an oscilloscope. First, we had to hang a shaker upside down. We hung the shaker upside down in a metal with approximate dimensions, three feet high two feet by two feet for its base. Then, we attached the spring to the vibrating part of the shaker. We used a very stiff spring that has the resonance frequency of about 5.6 cycles per second, and we attached it to the shaker. I manually adjusted the shaker, and I had the shaker do a broad band search.

For my last experiment with Dr. Lee, I connected a microphone to the FFT analyzer. I just spoke into the microphone, and then looked at the FFT readouts. I also tried to sing into the microphone, and I held high notes to see what they did, and I held low notes to see what they did.

Results and Conclusion

My results from the S-N curves were graphs. The graphs had four points, and showed how close the line of best fit was to them. For the most part the four points were very close to the regression line, and sometimes they were even on the regression line. Some data points are far from the regression line, and I would double-check those points to find that they belong closer to the regression lines. Human error was usually the problem that the points did not fit on or close to the line. Other times the point was not on the line because of the data point. With my calculator I checked to see how close in percents the points were to being on an actual line. Most of the time the correlation between the data points and the regression line was about 99%. All my graphs are log-log plots, so that the data plot would be a straight line, and the units looked much better (See Figure 1). Dr. Wolfe is going to use the graphs I made in a technical report which provides a quick way of comparing structures that one should use if he wants his airplane to last longer.

With Mr. Shimovetz I finished some sketches of the Hartmann Noise Generator for him. I drew top sketches and side sketches of the Hartmann Noise Generator. I also got the dimensions of the Hartmann Noise Generator. The diameter of the nozzle of the noise generator is 4.6 inches, and the length of the nozzle is 4.32 inches. The entire length of the noise generator is 18.32 inches. The length of the hose pipe adapter is 14 inches and its height is two inches. The piston is four inches long and one inch high. The piston slides back and forth to change the volume of the resonant cavity; hence, one could make

the acoustic test chamber louder or softer by increasing or decreasing the volume of the resonant cavity. Mr. Shimovetz and I decided on an actuator to put in the noise generator. The purpose of the actuator is to change the volume of the resonant cavity while acoustic chamber is running. We are going to put an AC linear actuator into the noise generator. I am not going to be able to see the Hartmann Noise Generator complete because my summer tour will be over.

The results of the first experiment were very simple. I did the trial five times, and the average was 140.3 (cycles per minute). Using the frequency equation, I was able to solve the equation for the spring constant since I knew the frequency and mass, and the spring constant is 107.16 cycles and grams per second. I also did the same test to another spring, and found that stiffer springs have higher resonances than softer springs because stiffer springs do not stretch as much as softer springs. Stiffer springs also have higher spring constants than softer springs.

Spring-mass systems have a nonlinear behavior when the spring is stretched too far. The experiment is to find out when the spring-mass system goes into its nonlinear stage of behavior. I again set up the spring on a stand, and attached the 500 gram mass to the spring. I put a one gram mass on the weight, and charted the data. Reading the data, the spring has linear behavior when the spring-mass system is pulled down an inch or less. When the spring-mass system is pulled more than an inch, the system shows nonlinear behavior. I arrived at this answer when doing the experiment. About every ten grams added to the spring-mass system brought the equilibrium system down .1 inches. The behavior was only linear when I added 100 grams or less. When the additional mass over 100 grams is added, a nonlinear behavior began to show up. The more mass I would put on the spring-mass system; the less the spring stretched from the previous position. Plotting my data, I found that the line is similar to the simple equation:

$$y=\sqrt{x}$$

Where y is change of equilibrium position, and x is grams added. With a softer spring I got the opposite way of bending than with a harder spring that I demonstrated first.

The next experiment I did was the displacement of vibrating mass experiment. I used an accelerometer for this experiment. The accelerometer was placed on the top of the mass. I pulled down the mass a little bit so I could make the spring-mass system vibrate. Again, the accelerometer measures

acceleration, and acceleration is the second derivative of displacement. The accelerometer was connected to the computer, and the data was shown on the computer monitor. I looked mainly at the time-history graph (See Figure 4) of the data the computer received. When the acceleration is zero, it corresponds to one of the extremes of vibrating spring-mass system. When the acceleration is at its peak, it corresponds to the equilibrium position of the spring-mass system. Acceleration and displacement correspond together, but one has to know where, and that is what I learned in this experiment.

The experiment with the shaker was a very different experiment. The accelerometer this time was connected to a FFT analyzer and an oscilloscope. The resonance frequency was at 5.6 Hz. I found the resonance by conducting a broad band sweep search between 2 and 10 Hz., and the highest peak is the resonance. I set the shaker to vibrate at 5.6 Hz., and the spring-mass system started bouncing very high. When I set the shaker to vibrate at 6.5 Hz., the spring-mass system vibrated unnoticeably to the eye, but when I touched the spring-mass system I could feel it vibrate. I looked on the oscilloscope when the shaker was vibrating at 6.5 Hz., and the oscilloscope was picking up very faint signals from the accelerometer. The oscilloscope picked up very strong signals from the accelerometer when the shaker was vibrating the system at 5.6 Hz. The oscilloscope picked up stronger signals when the shaker was vibrating the spring-mass system at 11.52, 17.25, 23.04, 28.8, 34.56 Hz.,... The reason these other frequencies are picked up better on the oscilloscope is because they are other higher-order resonances. The highest vibrating resonance is the first resonance and then the second and so on. Another graph I looked at was the power spectrum graph (See Figure 3), and the power spectrum graph gave me the other resonances because it shows distribution of energy contents over frequency range (g). The peaks in the graph are the resonances.

The next experiment I did was with the microphone. The microphone was connected to the FFT wave analyzer. The best thing about this experiment was that I was going to analyze my own sound waves. When I spoke loudly into the microphone, the larger the sound waves became, and when I spoke softly into the microphone, the smaller the sound waves became. When I sang high notes into the microphone, the frequency became greater, and when I sang low notes into the microphone, the frequency became low. When I tried to sing the note middle C, I noticed that it was not a perfect sine wave like a tuning fork would produce, and I noticed that I could not produce only one frequency, and that must be why a violin sounds richer than a flute.

References

Mechanical Vibrations by W.T. Thomson. Prentice-Hall: New Jersey 1959. Second Edition. Pages 18-42.

"High Level High Frequency Noise Generation In The NAE Spacecraft Test Chamber" by R. Westley, M. J. Brown, M. Baranowski, National Research Council of Canada. Pages 136-148.

Figures

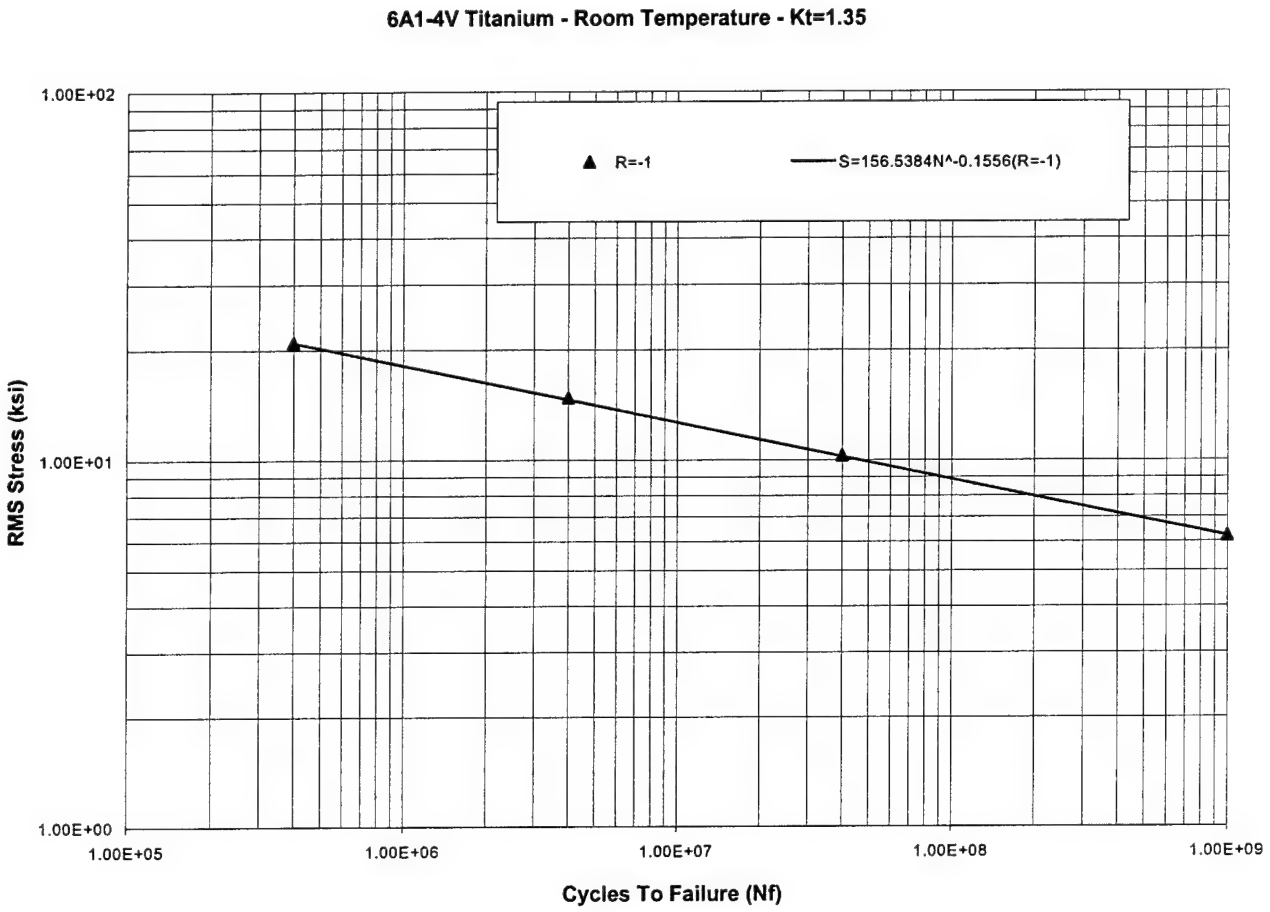

Figure 1 – S-N Curve and Data Points

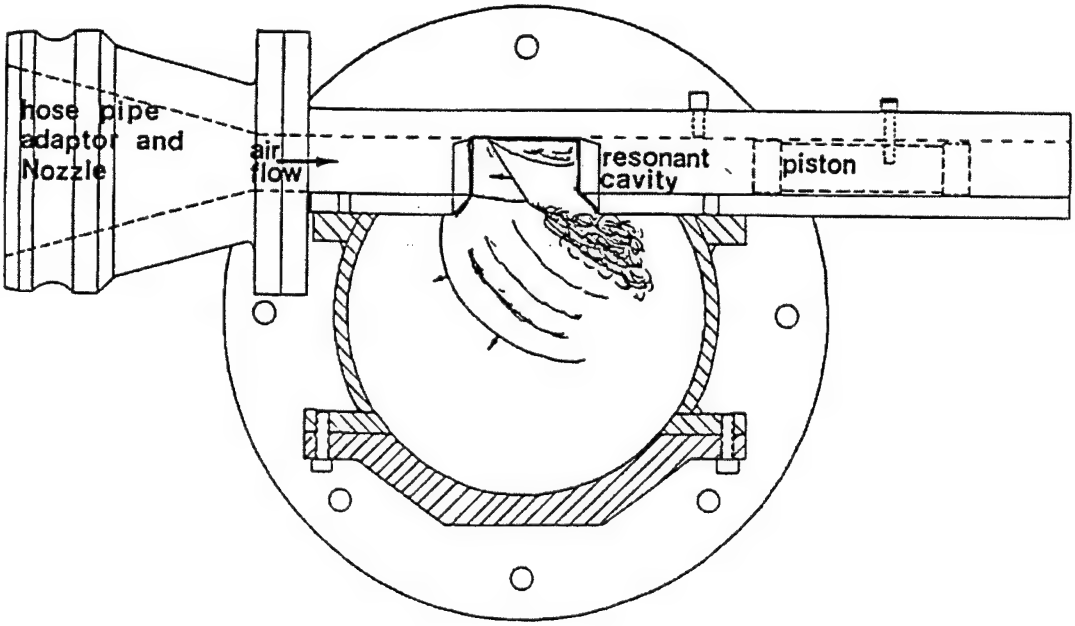

Figure 2 - Hartmann Noise Generator

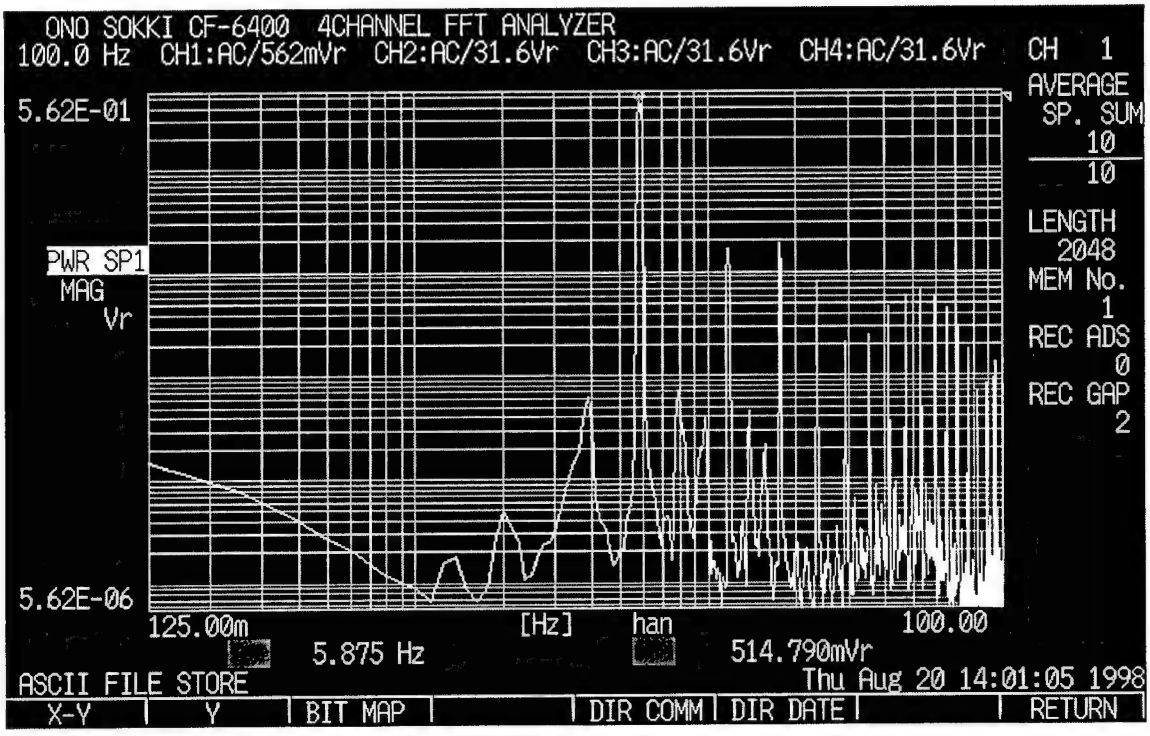

Figure 3 - Power Spectrum

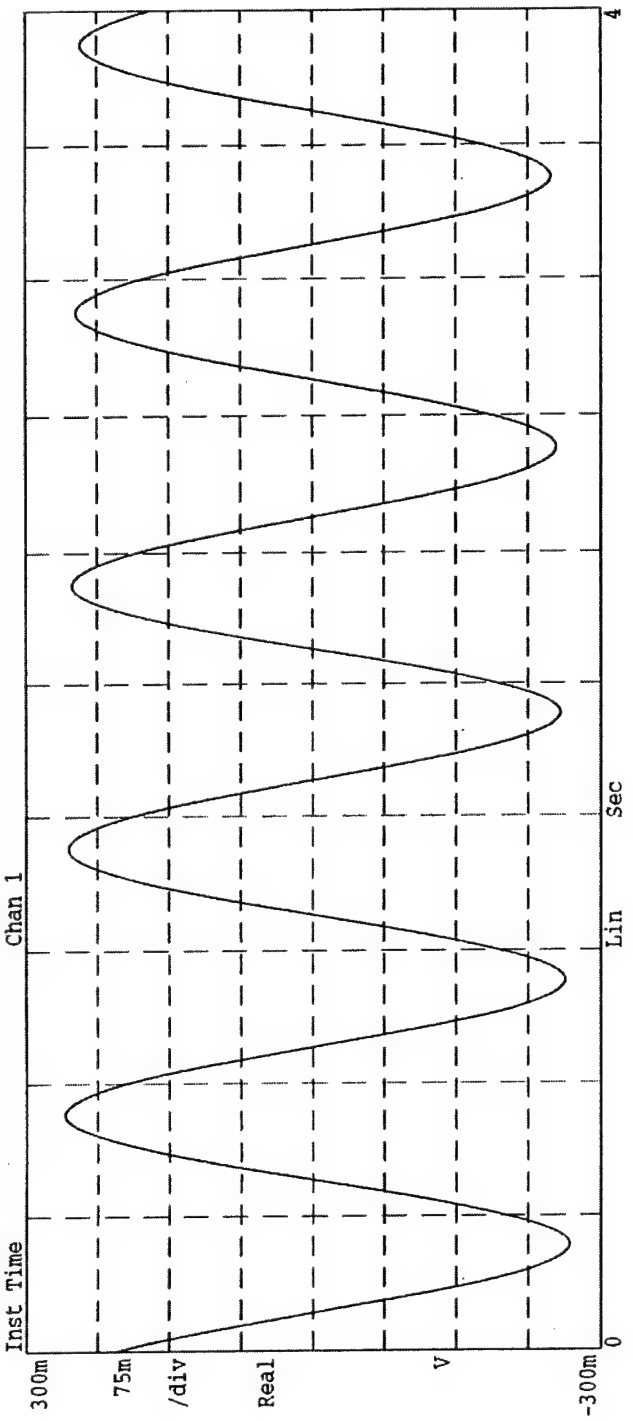

Figure 4 – Time-History Graph

COMPUTER SOFTWARE EXPERIMENTATION AND MODIFICATION

Tracey E. Fitzgerald

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

And

Wright Laboratory

August 1998

COMPUTER SOFTWARE EXPERIMENTATION AND MODIFICATION

Tracey E. Fitzgerald
Port St. Joe High School

Abstract

My objective is to present the reader with details concerning my experiences as part of the high school apprenticeship program. I worked in Pavements and Facilities for eight weeks, dealing with many computer issues that were new and challenging to me. Among these are: utilizing programs such as Microsoft Access, Visual Basic, and PowerPoint; the entering of data by way of a scanner; the importing and exporting of text, tables, and graphics; database design, including forms, tables, queries, and reports; program design, including actual code writing; PowerPoint presentation preparation; DPlot data modification; and last, a greater familiarity with computers in general.

COMPUTER SOFTWARE EXPERIMENTATION AND MODIFICATION

Tracey E. Fitzgerald

Introduction

I had envisioned a summer of rolled up shirtsleeves, knee-deep in Bonita Bay as I tested for some trace toxin. Needless to say, I viewed the dusty warehouse at Pavements and Facilities with a certain amount of trepidation. I went over my job description once more in my mind. *"The student will be participating in a project entitled 'Computer-Based Decision Aid.' This is a technical project being conducted by AFRL/MLQCTP for AFCESA/CESA. The overall objective of this project is to develop computer-based tools for use by AFCESA's Pavement Evaluation Teams... "* It wasn't exactly what I had been expecting. Despite my early hesitation, however, my experiences here have been very beneficial to me. Working here has advanced my knowledge and level of comfort with technology, as well as having helped me with my career choices for the future.

Over the course of eight weeks, I participated in two main projects. Each involved a certain extent of computer programming and data manipulation. Through experimentation and trial-&-error, I became familiar with many different computer programs. Among these are: PowerPoint, Microsoft Access, Visual Basic, and DPlot. I became proficient at scanning documents for editing and/or use in presentations. I was able to assist in the entering and manipulation of pressure-related (DPlot) data. I was even able to grasp and utilize the fundamentals of the Visual Basic program. These are only a few examples of the flood of information that I was exposed to this summer. In the following paper, I attempt to outline the things that I participated in and the knowledge that I gained.

Work Experiences

Scanning

For two days, I became acclimated. I then began my third day (and effectively, my eight-week tour) by operating a Hewlett Packard ScanJet scanner. Once I mastered the technique of feeding the machine and scanned my first document, I began to adjust the settings to find which setting worked best with which type of document. For text documents, as long as the text is heavy and dark on the original paper, it will scan into a computer well, needing minimal cosmetic touch-ups. If the paper is off-white, or if the data is a smaller graphic image, the best settings are usually an increase in contrast and a decrease in brightness.

Scanning cont.

If the paper is darker colored, brightness and contrast should both be increased. The contrast setting affects only the text/graphics, while the brightness setting affects the text/graphics and the background they are on. After I became proficient in the physical use of the scanner, I began to learn how to manipulate the data that I entered into the computer. This brought me into contact with various programs. Among these are Hewlett Packard PaperPort and Microsoft PowerPoint. After an image was scanned, it was transported directly into PaperPort, where I could focus, flip, and resize it. After I was satisfied with the appearance of the image, I could export it to a number of different programs. Some went to Paint for further editing and were saved as bitmap (*.bmp) files. Others went to PowerPoint's clip gallery as JPEG (*.jpg) files. Still others were converted into Excel files, using the (*.xls) file extension. The ultimate fate of most of the scanned images lay in adorning a PowerPoint presentation or Excel worksheet.

One of my first tasks was to create a schematic using Microsoft Paint. I did this easily, using the available tools to draw boxes and connectors, to cut and copy, and to insert text. The construction itself did not present a problem, but it allowed me to come to a greater understanding of the physical side of computers (see example of schematic – Appendix E).

Microsoft PowerPoint

One of the first programs that I used was Microsoft PowerPoint, a presentation-design application. I would often use PowerPoint to prepare presentations for meeting or reference. I began a presentation by choosing an auto-format. Often, the layout consisted of the title, information, and clipart or a scanned image. After all of that was in place, I could insert text or picture boxes as needed. Eventually, I was able to start a presentation from scratch and design my own layout (see example – Appendix A).

Microsoft Excel

Microsoft Excel played an important role in many of the things that I did. For example, it was often the destination of scanned documents or information. It was used to develop much-needed parts lists (see example – Appendix F) and was the "drop-point" for documents that would be converted into Microsoft Access database files (see example – Appendix G).

Work Experiences

Microsoft Visual Basic

As I worked with PowerPoint and Excel, I was preparing for the real phase of my job: database design and upkeep. I did this by installing Microsoft Visual Basic and taking part in a 21-day self-taught course. Surprisingly, it was much easier than I had expected. I quickly completed all of the lessons but the final two (due to a lack of needed software). Eventually, I was able to recognize and write code commands, as well as develop the visual part of the programs.

I began by attaching menu bars, scroll bars, text boxes, labels, and command buttons to a blank form. After completing the visual portion (the part that the user actually sees and manipulates), it was necessary to attach code to each item. Without code, each visible item would be meaningless. For example, if the user were to click the Exit button, the program would not respond in any way. (See example of VB program – Appendix B).

Microsoft Access

After learning the fundamentals of Visual Basic, my next task was to design a computer database that would contain and organize all information concerning computer hardware and software in Pavements and Facilities. I began by taking an inventory of all of the hardware and attached software in the Pavements building. It was organized as follows: Employee Name (or Name of Responsible Party), Hardware, Attached Software, Serial Numbers (see example – Appendix C). Once the inventory was finished, I entered the information into customized fields in Microsoft Access. After completing this phase, it was possible to query all of the information to print out customized reports (see example of report – Appendix D). The desired result, however, was to be bale to view the information cell by cell. In order for this to occur, a Visual Basic program had to be built. It was simple in design; a text box and a few command buttons were placed on a blank form. Customized code was then entered to allow the program to function properly. After running the program, the specified Access cell of information would appear in the Visual Basic text box. The user would then be transported into Microsoft Excel and a pie graph would automatically open. The graph was pre-labeled and organized (per the code commands). The values would change as the specified cell changed.

Work Experiences

DPlot

At the start of my fifth week, I began to work in a different area of Pavements. I was still using computers, but my work came straight from field data. In essence, a structure would be designed, built, and blown up. Data would be measured and recorded during the blast. Using the DPlot program, I entered the pressure-related data into a computer, then manipulated the product to produce a finished, labeled graph (see example – Appendix H). After titling the graph, I would integrate a curve through the data processing procedure. It was then possible to determine certain points (for example, the point of highest pressure) and add labels.

Summary

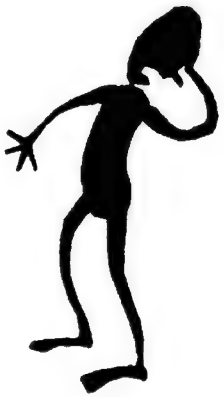
In conclusion, I gained a great deal of valuable computer-related knowledge. Not only am I proficient at scanning, creating presentations, and manipulating data, my typing speed has increased ten-fold. Each individual task that was set before me became part of a bigger picture. Through the many new programs that I was exposed to, in which I had to learn to maneuver on my own, I am now able to face new and challenging computer issues with an arsenal of knowledge and confidence.

Appendix A

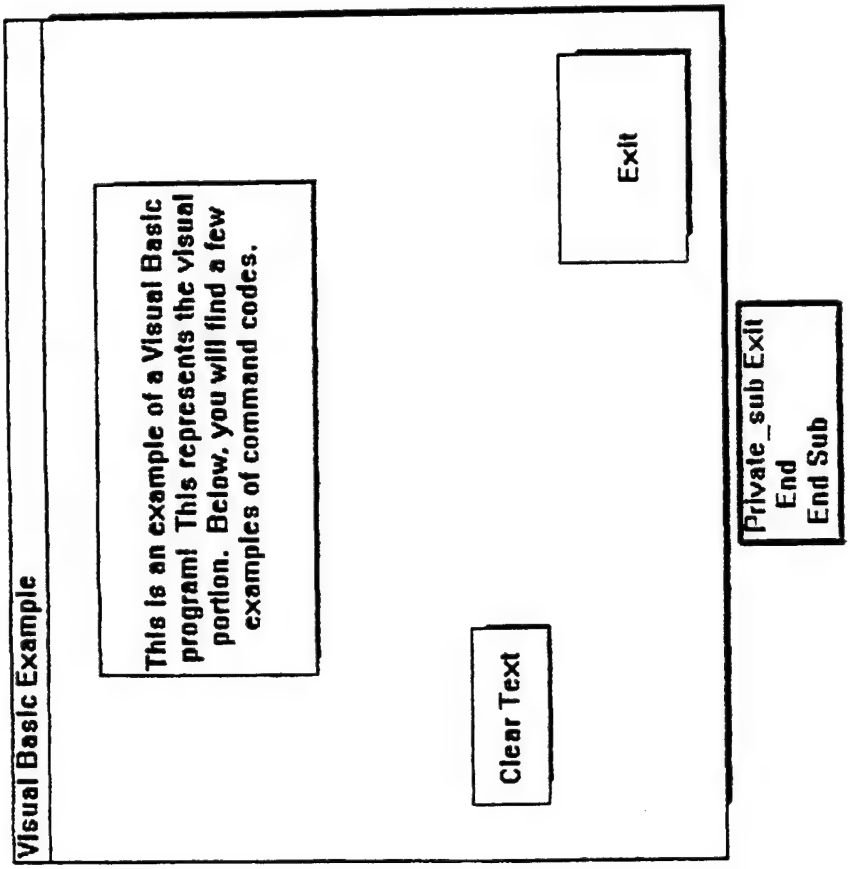
PowerPoint Example

This is an example of the presentations that I designed during my apprenticeship.

Usually, I would insert a scanned image instead of a clipart picture (see right). Often, the image would have to be imported to the clipart gallery as a JPEG (.jpg) file.*



APPENDIX B


Visual Basic Example
This is an example of a Visual Basic program! This represents the visual portion. Below, you will find a few examples of command codes.
Clear Text
Exit
Private_sub Exit
End
End Sub

APPENDIX C

Patrick, Tim

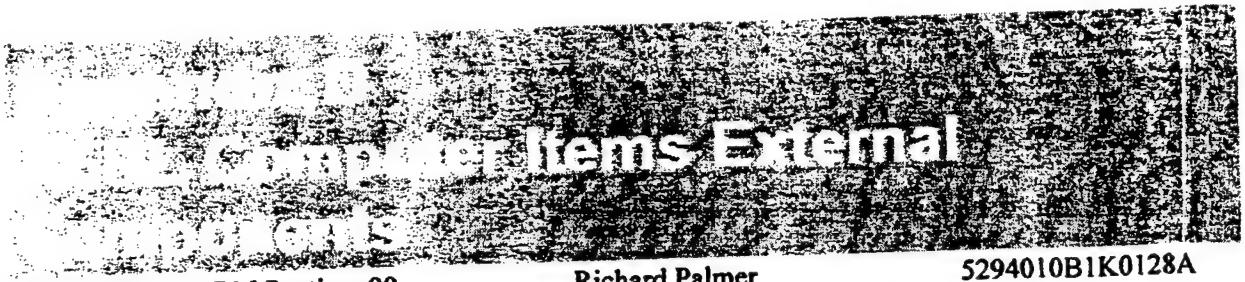
Component - Gateway P5-133

Category: Monitor - 17" Mag Innovision
Printer - HP Color LaserJet 5/5M
Scanner - MUSTEK flatbed

Once the inventory list above was completed, including software and serial numbers, all of the information would be entered into the computer database. After that was done, customized reports could be printed based on queries.

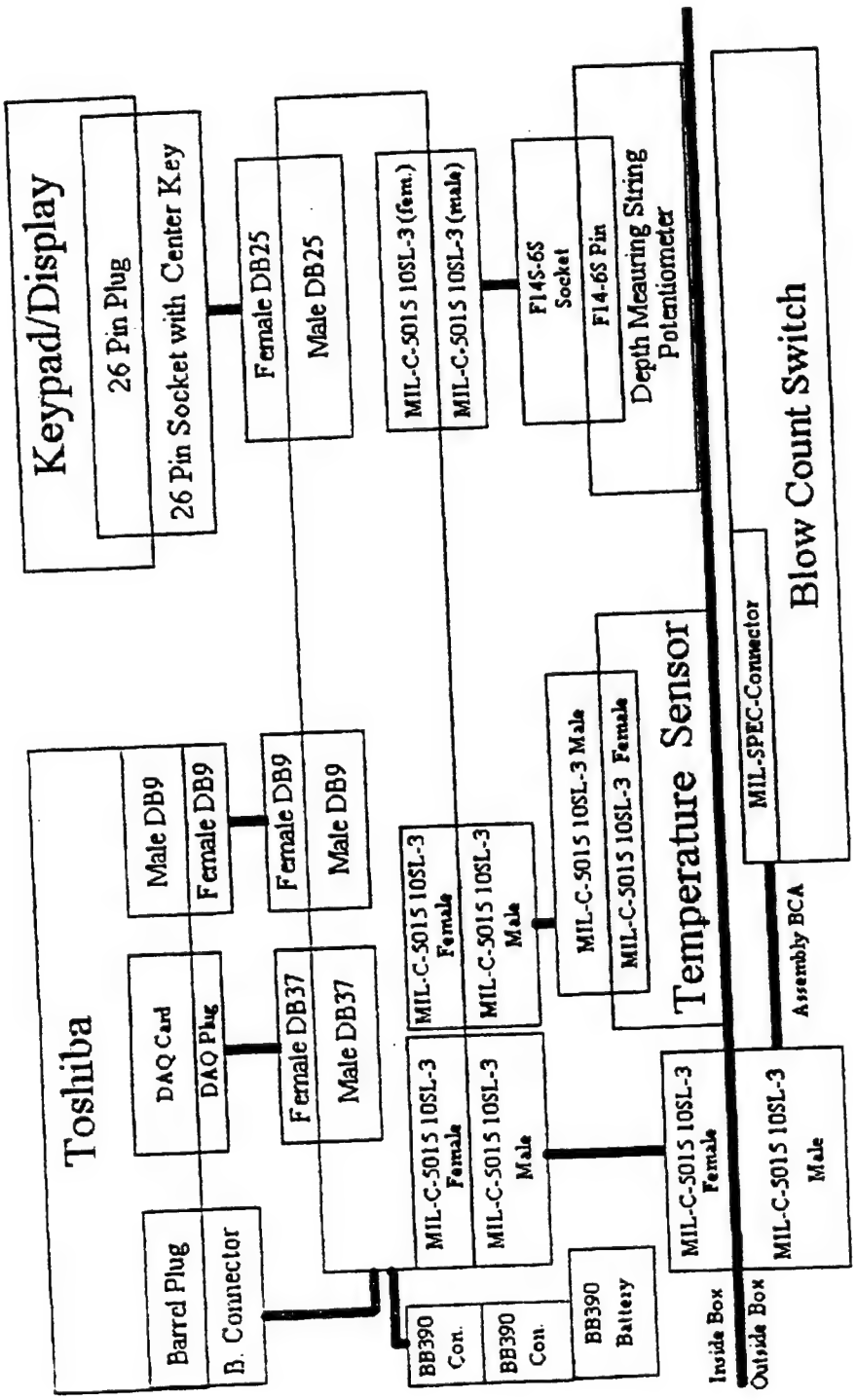
Other information included:

zip drives (?)
jaz drives (?)
UPS systems (?)
external modems (?)



Component	ARM Pentium 90	Richard Palmer	5294010B1K0128A
	16 MB RAM, 687 MB hard drive *(DAQ)		
Component	**Category**	**Item**	
Component	Gateway P5-200	Mike Purcell	TBD10
	48 MB RAM, w/ zip drive		
Component	**Category**	**Item**	
	Speakers	Creative CS46	
	Printer	Okidata OL-600e	
	Monitor	Vivitron	
Component	Gateway P5-133	John Porter	TBD11
	w/ zip drive		
Component	**Category**	**Item**	
	Printer	HP LaserJet 5MP	
	Scanner	Microtek ScanMaker 600Z	
	Monitor	Vivitron 17"	
Component	Gateway	Tim Patrick	TBD12
	64 MB RAM, 1 hard drive 5 GB, other 1.6 GB, w/ zip drive and jaz drive		
Component	**Category**	**Item**	
	Monitor	17" Mag Innovision	
	Printer	HP Color LaserJet 5/5M	
	Scanner	MUSTEK scanner	
Component	Gateway4DX2-66	Penny Pippin	TBD13
	36 MB RAM, has NO sound card		
Component	**Category**	**Item**	
	Printer	HP LaserJet 4000	
	Monitor	Sony Trinitron Color Display	

APPENDIX E


Keypad/Display
26 Pin Plug
26 Pin Socket with Center Key
Female DB25
Male DB25
MIL-C-5015 10SL-3 (fem.)
MIL-C-5015 10SL-3 (male)
F14S-6S Socket
F14-6S Pin
Depth Meauring String Potentiometer
Blow Count Switch
MIL-SPEC-Connector
Assembly BCA
Temperature Sensor
MIL-C-5015 10SL-3 Male
MIL-C-5015 10SL-3 Female
MIL-C-5015 10SL-3 Female
MIL-C-5015 10SL-3 Male
MIL-C-5015 10SL-3 Female
MIL-C-5015 10SL-3 Male
Toshiba
Male DB9
Female DB9
DAQ Card
DAQ Plug
Female DB9
Male DB9
Female DB37
Male DB37
Barrel Plug
B. Connector
BB390 Con.
BB390 Con.
BB390 Battery
Inside Box
Outside Box

EXAMPLE OF PARTS LIST MADE IN MICROSOFT EXCEL

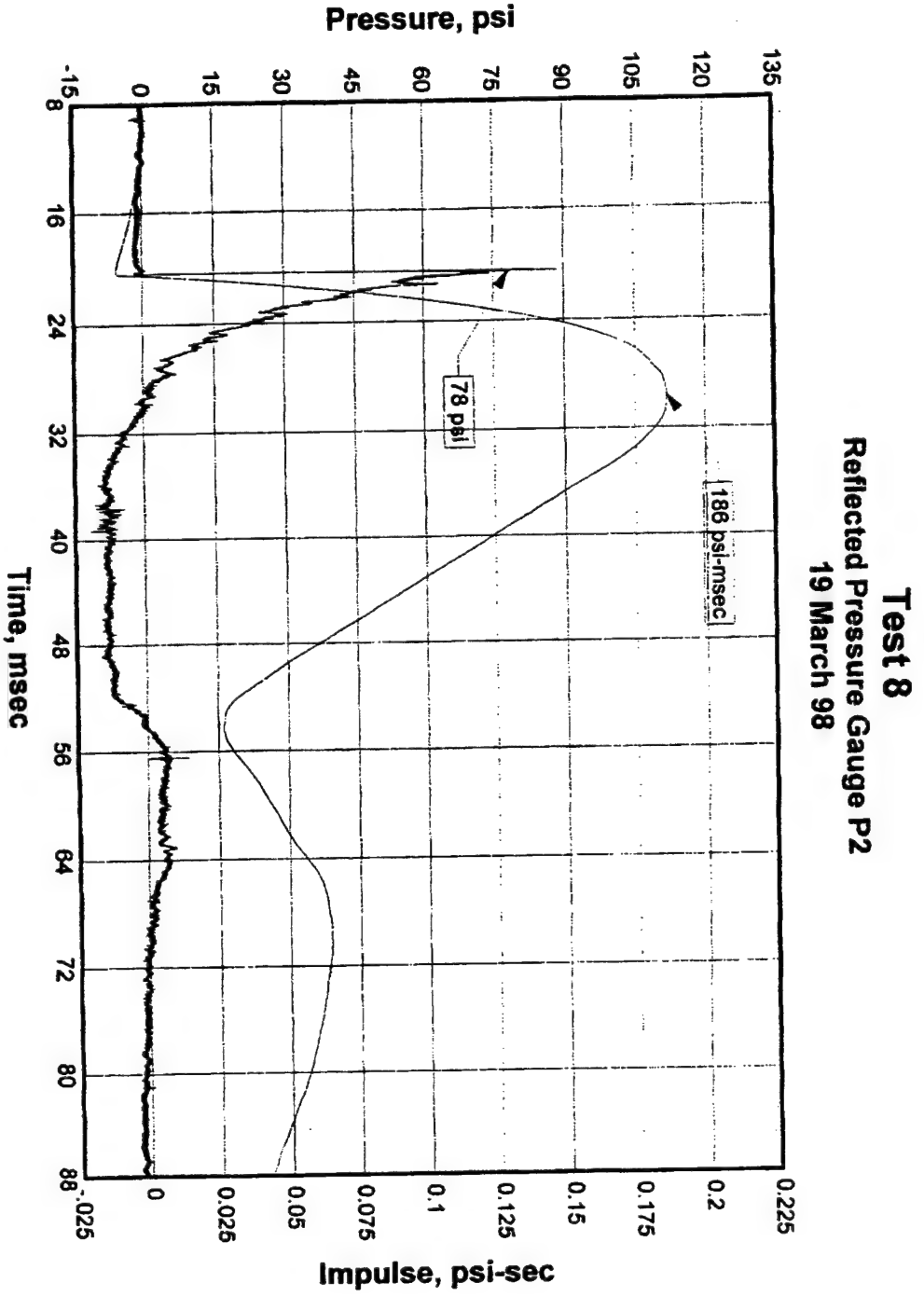
Quantity	Units	Description	Catalog/Vendor	Inventory	C/V Description
		Complete OTS Parts		TBR	
1		Automated DCP Transportation Container	Pelican Products	" "	Big Box
1		Data Acquisition Unit	Pelican Products	" "	Small Box
1		Depth Measuring String Potentiometer	UniMeasure, Inc.	" "	String Potentiometer
1		BB390 Battery			BB390 Battery
1		Toshiba Libretto	Toshiba	" "	Toshiba Libretto 70CT
1		Keypad/Display	Intelligent Instrumentation	" "	Microterminal
1		DAQ Card	Keithley	" "	KPMCIA-12AIAO
		OTS Cables			
1		TMA037 Connector	Burr-Brown	" "	
1		KCAB-AIAO Cable	Keithley	" "	
		Power/Signal Distribution Assembly			
1		Power/Signal Distribution Box	?	" "	Electrical Enclosure Box
3	ft	single strand wire - X awg		" "	
1	ft	2-wire Power Cable - X awg	?	" "	Connector
1	ft	5-wire Power Cable - X awg	?	" "	Connector
1		15 Volt output Voltage Regulator		" "	
1		5 Volt output Voltage Regulator		" "	
1		BB390 Plug		" "	
1		Barrel Connector		" "	
3		Female MIL-C-5015 10SL-3	ITT Cannon	" "	
1		Male DB37	AMPLIMITE	" "	
1		Male DB25	AMPLIMITE	" "	
1		Male DB9	AMPLIMITE	" "	
		Temperature Sensor Assembly (TSC)			
1		Temperature Sensor	Newark	" "	Temperature Sensor
1	ft	3 wire cable		" "	
1		Male MIL-C-5015 10SL-3	ITT Cannon	" "	Male Mil-C-5015 10SL-3 Connector

EXAMPLE of Text Document imported into Microsoft Excel

New Feat	Facility Identity	Area SqFt	Pavement Cond	Thick Descrp	Base Descrp	Flex Thick psi	SubBase (in)	Thick Descrp
	A01B		Warm-up 6	Apron Runway		16.25 PCC		675
	A02B			ArmyApron		7.00 PCC		2300
	A03B			ArmyApron		3.75 AC		200
	A04B			AirNational Guard Apron		14.00 PCC		13
	A05B			AeroClub Hangar Apron		5.50 PCC		150
	A06B		Abandoned	Apron		9.00" @ SP-SM F2		250
	A07B			WestApron Romeo (Ramp)		16.00 PCC		775
	A08B			WestApron Romeo		16.00 PCC		300
	A09B			WestApron Guard Apron		16.00 PCC		300
	A10B			AirNational Hangar Apron		12.75 PCC		350
	A11B			ArmyApron Guard Apron		4.50 AC		1900
	A12B			AeroClub Hangar Apron		14.50 PCC		1875
	A13B			AirNational Abandoned		3.75 AC		122

APPENDIX G

APPENDIX H


Test 8
Reflected Pressure Gauge P2
19 March 98
Pressure, psi
Impulse, psi-sec
Time, msec
78 psi
186 psi-msec
135
120
105
90
75
60
45
30
15
0
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
-.025
-15.8
16
24
32
40
48
56
64
72
80
88

TWO-DIMENSIONALMULTIPLE-FRAME IMAGE ANALYSIS

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Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

And

Wright Laboratory

August 1998

TWO-DIMENSIONAL MULTIPLE-FRAME IMAGE ANALYSIS

Jeffrey L. Friedman
Niceville High School

Abstract

The purpose of this summer project was to begin work on an algorithm that would effectively locate and track a moving target in a sequence of digital radiance images. At completion, this algorithm is projected to be capable of locating moving targets in a high-clutter environment. It will also be fast enough to be implemented in real time. The developed algorithm uses contrast enhancement, edge detection, image differencing, and pixel masking to analyze its input. It currently can track targets in low-clutter environments, but further work will be needed in order to deal with data obtained from a dynamic source (e.g. a moving camera) in high-clutter environments.

TWO-DIMENSIONAL MULTIPLE-FRAME IMAGE ANALYSIS

Jeffery L. Friedman

Image processing deals with the modification and analysis of pictures. Images are generally processed using digital computers, but can also be processed by optical, photographic, and electronic means. Digital operations are currently favored because of their speed, precision, and programming flexibility. As technology matures, analog image-processing methods may become more commonly practiced, but for now they are too costly and time consuming.

In a typical image-processing system, the source of the image is visible light reflected off various objects in a scene. The light is gathered and focused onto an electronic sensor that produces an impulse proportional to the radiance of the inputted light. This impulse is then converted to a numerical value on a given scale and stored in a two-dimensional array. Infrared and ultraviolet rays can also be used as a form of radiance input. Not all digital images represent radiance, however; input representing distance can come from radar, sonar, and ladar. In either case, the two-dimensional array of numbers obtained is the digital image. Each number in the array is called an element or a pixel. A typical size of a digital image is an array of 512 by 512 pixels, where each pixel stores 8 bits of data or 256 (2^8) colors.

After an image is contrived it can be processed. The image itself can be changed or enhanced in an attempt to make it easier to see or analyze. For instance, the contrast of the image may be increased. Because image processing deals mainly with a pixel's radiance compared to its neighbor's radiance, it is helpful to have the values of all the pixels in an image (or set of images) cover the entire range. If an 8-bit image (range of 0-255) having values ranging only from 0-20 was processed without contrast enhancement, there is a good chance that detail would be lost. Contrast enhancement is can also pleasing be to the human eye (Figure 1).

Before

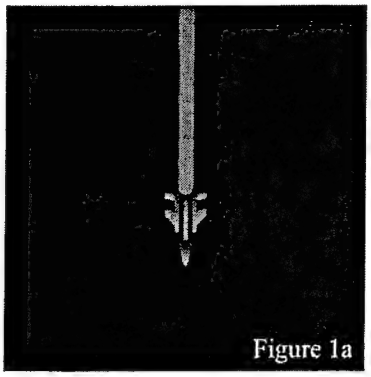

Figure 1a

Contrast Enhancement

After

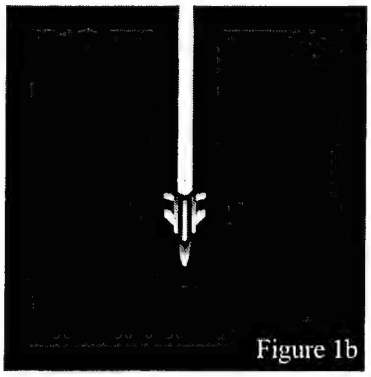

Figure 1b

Another operation similar to contrast enhancement is edge detection. In the same way that contrast enhancement compares the values of the pixels of the entire image to each other, edge detection compares the value of each pixel to its neighboring pixels (generally the 8 adjacent pixels). Edge detection is generally used to analyze extended targets (larger than a few pixels). Edge detection works by assigning each pixel with the absolute value of the difference between its former value and the average value of its neighbors. The result is high radiance along the edges of objects (Figure 2).

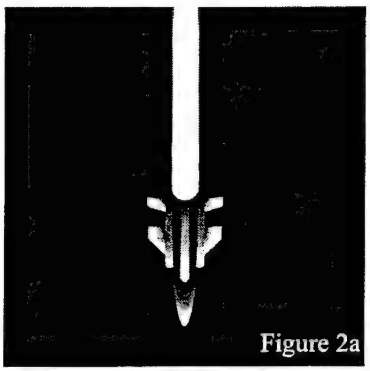

Figure 2a

Edge Detection

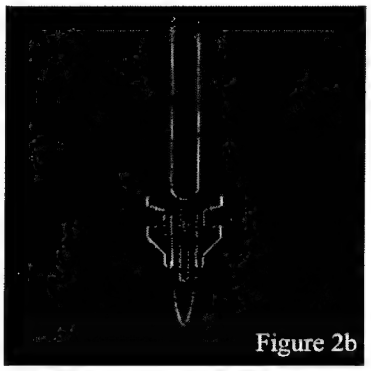

Figure 2b

Contrast enhancement and edge detection are examples of an operations performed on a single image, comparing the components of that image to each other. When a sequence of images is provided, however, pixels of adjacent images can be compared to each other for further analysis. This is especially effective when the background of the image is static and the object that is desired to be located is in motion. One technique for comparing images is image differencing. Image differencing takes two (or more) images and compares the values of corresponding pixels to find changes between the images. The result is high radiance in areas of motion (Figure 3).

Frame Differencing

Image 1 Image 2 Difference

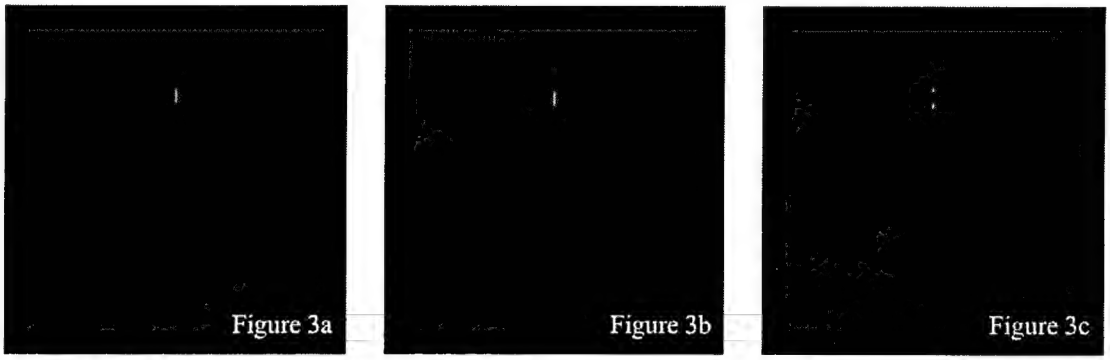

Figure 3a Figure 3b Figure 3c

Pure frame differencing, although effective in certain circumstances, has its drawbacks. Frame differencing only works when the backgrounds of the images are at least semi-static, that is, the source of the images remains quasi-stationary. This would be somewhat unrealistic for a situation such as missile guidance considering the sensory equipment is usually carried by the missile itself.

The purpose of this project was to begin work on an algorithm to track a target in a sequence of images. The current algorithm incorporates contrast enhancement, edge detection, and frame differencing, and bit masking (not yet discussed). Note the following flow chart (Figure 4).

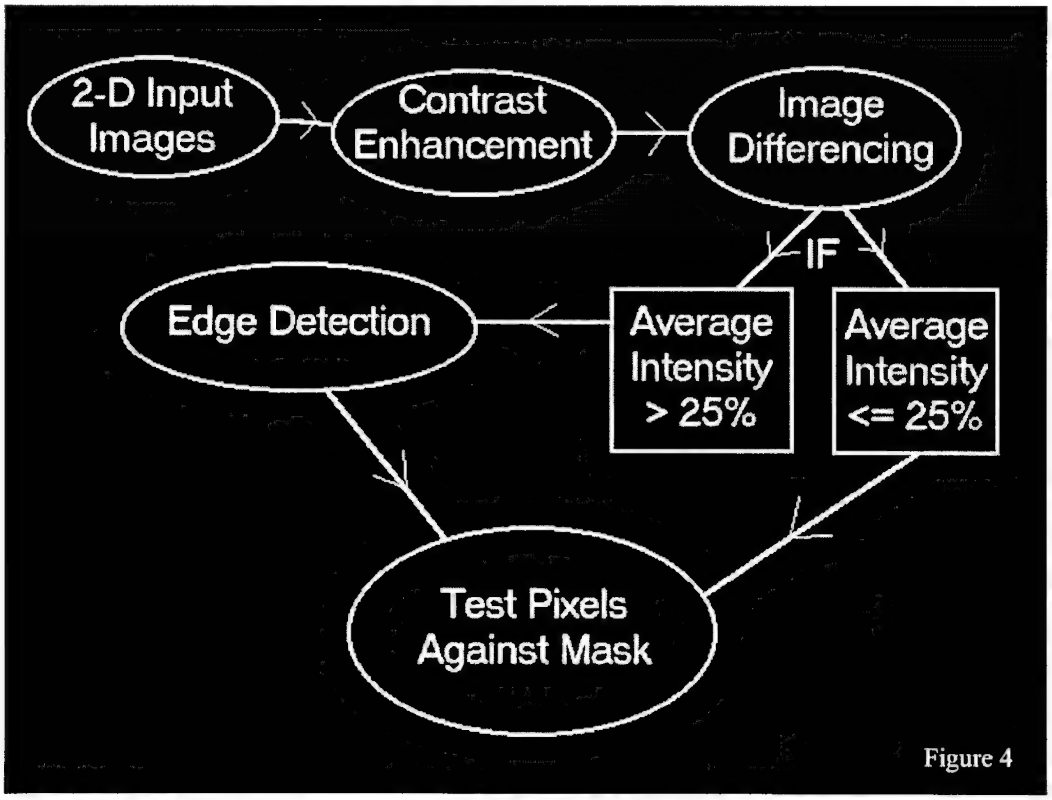

Figure 4

Upon receiving the first 2 images in the sequence, the algorithm does the following:

1. Enhances the contrast on both images so that pixels fill the range

2. Take the difference of the two images

3. Find the average intensity per pixel of the differenced image

4a. If the average intensity per pixel is greater than 25% radiance then perform edge detection on the contrast enhanced image (the reason for this is because if the radiance is over 25% then there is too much motion occurring between the two frames, e.g. the background is in motion)

4b. Test the pixel mask against the edge-detected image

5. If the average intensity is less than 25% radiance then test the pixel mask against the frame-differenced image

Using a pixel mask is a simple way to find a certain shape within a picture. It makes several assumptions, however, and is just a temporary solution for object recognition. Figure 5 shows the pixel mask used in this project.

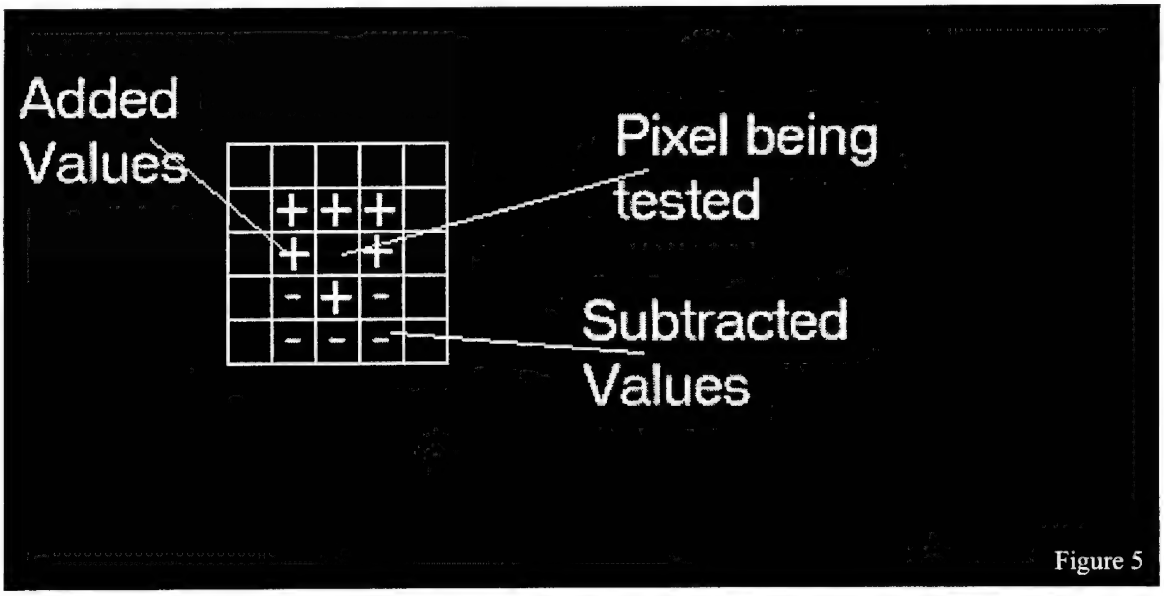

Figure 5

The pixel mask is tested on every pixel in the array and saves the coordinates of the pixel whose mask has the greatest value. It is a search for an area in the image where there is a region of high radiance

with a certain shape (in this case the shape of a missile nose cone) and an area of low radiance surrounding it. By adding the values of the pixels that would make up the specific shape and subtracting the values that would be low-radiance background and assigning that value to the pixels mask, the pixel with the greatest value is the one which has the greatest chance of being the target. The current pixel mask assumes that its target is perpendicular relative to the camera. Such simple pixel masking will probably not be used in the final algorithm so that these assumptions will not have to be made.

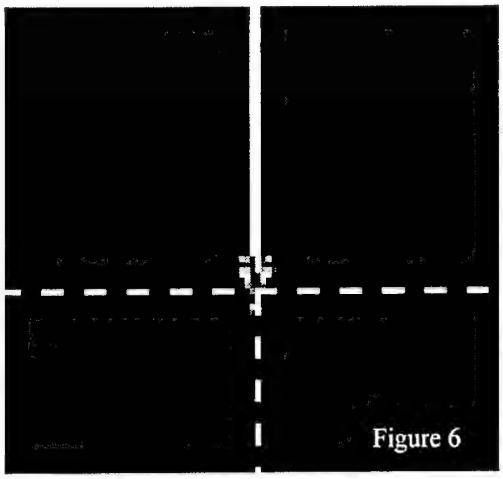

Figure 6

A successfully located target in a low-clutter, non-static background

An example of a successfully located target in a very-high-clutter, semi-static background (Figure 7)

Frame 1

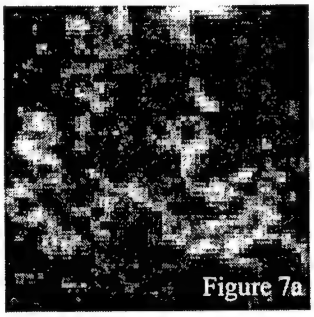

Figure 7a

Frame 2

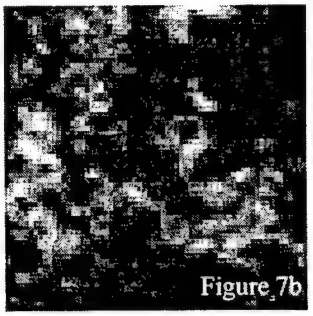

Figure 7b

Note: The target is invisible before frame differencing.

Frame difference

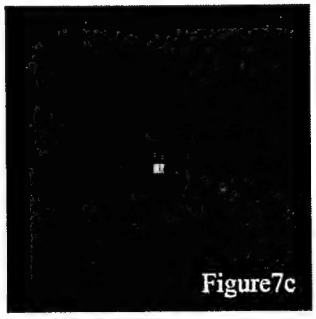

Figure7c

Target located with pixel masking

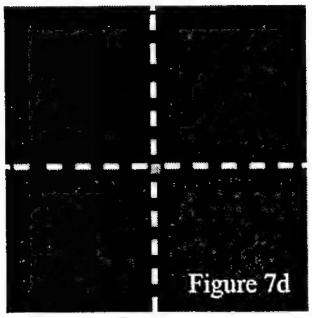

Figure 7d

This algorithm has been shown to be effective in low-clutter scenarios with a moving background (Figure 6) and in high-clutter scenarios with a semi-static background (Figure 7). More research will have to be conducted before the algorithm is capable of finding targets in high-clutter/non-static sequences. Future plans include research in the areas of motion parallax, neural networking, and the combination of image differencing and edge detection.

FOLLOWER OF DAN THE "LAN" MAN

Adria D. Gaitros

Mosley High School
501 Mosley Drive
Lynn Haven, FL 32444

Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

And

Wright Laboratory

August 1998

FOLLOWER OF
DAN THE "LAN"MAN

Adria D. Gaitros
A. Crawford Mosley High School

Abstract

This year I shadowed a network administrator. This proved a useful learning experience for when I need to fix my own computer. He mentored me in the skills of troubleshooting and how to find my way around a network. Part of my job here was to set up a network help desk and run it while my mentor left for two weeks. He entrusted me to fix all computer problems while he was away. On the side of learning about computers, I also helped in the Technical Information Center. There I spent my time researching for the scientists in the lab and giving them the needed information for their studies. There also were various other jobs that filled my time. The opportunity came up to learn how to make a web site and create one for the office I worked for. One administrator gave me the task to learn how to use the office's database and create a short cut sheet for those who did not know how to maneuver their way around. This job gave me the experience needed to ready myself for a job in the future.

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My mentor gave me many tasks that required me to handles a lot of vital information. This information consisted of passwords and how to change a problem with a network user. He gave me the task to put a new antivirus program on everyone's computer. This task made me learn my way around the local area network (LAN). I observed all the steps he want through first, and then I went out on my own. There were approximately one hundred and twenty computers that I had to add this antivirus to. It took me about a week and a half to fully complete this task. I had to work around the office's schedule. When they were away from their desks I loaded the program.

After I completed this task, my mentor gave me another. He taught me how to insert hard drives and format them for new computers. I learned through this experience about static electricity and how it can wipe out an entire hard drive. Now I know to ground myself before handling any computer parts. Once I got out the hard drive I proceeded to hook it up to a different computer. The hard drive in the

different computer becomes the master hard drive and the hard drive from the new computer becomes the slave. Once the I connected the slave hard drive, I could copy information from the master hard drive. This proved efficient because I did not have to go through and install every program on the hard drive. Then I returned the slave hard drive to its original computer. After I turned the computer on I gave it a name and set defaults for Netscape. This task gave me the knowledge to do the next job. My mentor gave me a brand new computer and told me to set it up in the Technical Information Center. Since I had never done this before it was a good experience for me. I learned how to put in various cards for different devices and how to hook up all the cords and plugs.

About half way through the summer, my mentor left for a two week conference. Since he is the network administrator he needed someone to fix all the problems while he was away. To solve this problem he left me to create a troubleshooting desk or as I call it "The LAN Trouble Desk." My mentor sent out a network e-mail to inform all the users that a desk existed to help with all their network problems. They were to call me whenever they had major network problems. To record all of these calls, I created a form to fill out with all the information needed to help a user. I also found a program specifically designed to serve as a database for a trouble desk, The Expert Support Program (ESP). This trouble desk gave me the experience I needed to help myself with problems in the future.

I spent many hours in the Technical Information Center (TIC) trying to help the librarians with their work. When I was in the TIC I would help the scientists with their research. They would request certain types of articles and my job was to find them and copy them so they could keep it. I also sorted and opened mail when needed. When I was not busy in the TIC I would search out people who needed copies made or filing done. For three days I went to help a lady file stacks of papers. She was desperately behind schedule and I was happy to help.

Captain Anderson gave me a project dealing with websites. He installed Front Page Editor onto my computer to allow me an easy way of forming a website. The purpose of this website was to show all those interested, the projects that the Air Force Research Lab are working on. The users of this website

could also be able to download software or documents related to that project. Since this was a new program for me I had to learn it on my own. I figured out that this program writes the necessary code required for each color, command, hyper-link, or word that you put on your web page. So you can create the page, see the code and how it is set up, and also see the final product with this program. After I finished the website, I could see how this job might be a good one for the future. Everyone wants their business on the Internet, so a web page designer is a good job for the future.

The last small project I assigned to me was to learn to use some of the databases the office used and then create a cheat sheet. There were two databases that the office used the most, the Reports database and the Eqinfo-7 database. I took about four days to simply look around these databases and print up some information. After I found my way around I started to create a form that provided a step by step way around the databases. I wrote it very easy and each step detailed so those who did not know it very well could use it without any problems. I created a brief on the databases to introduce the document, after I completed the cheat sheet. About ten people showed up and I taught them how to use the paper. I also created a disk with the cheat sheet on it so whenever needed a copy existed.

This summer has given me the insight into what a business environment is like. I learned how the rank system is too. I high school student is considered the lowest person there and we get all the grunt work. I figured out that if you were walking around people automatically think that you have nothing to do so as a high school student I was given plenty to do. I would like to become a chemical engineer and I took this job thinking that I would be put in a lab situation, but that didn't work out. The business side of things is not as fun as the lab side, but I had a good summer.

SUMMARY OF SUMMER WORK ON A SEARCHABLE DATABASE THAT CONTAINS THE PSSL'S TECH REPORT LIBRARY

David L. Greenwood

Oakwood High School
1200 Far Hills Avenue
Dayton, OH 45409

Final Report for:
High School Apprenticeship Program
AFRL/Wright Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

And

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August 1998

SUMMARY OF SUMMER WORK ON A SEARCHABLE DATABASE THAT CONTAINS THE PRSL'S TECH REPORT LIBRARY

David Greenwald
Oakwood High School

Abstract

A database that contains most (200+) of the tech reports in the PRSL's tech report library was created. This report briefly summarizes what I did and how the database will be used in the future. This report also includes the Procedure Manual for Personal Librarian and the Access Based TR Entry system.

SUMMARY OF SUMMER WORK ON A SEARCHABLE DATABASE THAT CONTAINS THE PRSL'S TECH REPORT LIBRARY

David Greenwald

Over time the tech report library for PRSL has become rather large. It has grown to the point were there is 200 plus tech reports in the library. Up until now finding a Tech report has not been an easy process. The only way to find a Tech Report that is contained in PRSL's Tech library has been to use trial and error. You would look at our out of date list of all the tech reports and scan the titles and hope that you found something that sounded like what you were looking for, or you had to have previous knowledge of the report and when it was written.

The DataBase was created in Microsoft's Access. But not everyone in the office has Access. So a different search engine needed to be found. One was located. PLS's Personal Librarian, a free search engine, was selected because it had a fuzzy logic search and it was free. PL does not come with a data entry system so I continued to develop an Access based data entry system.

The ultimate goal of the project is to have all of the Tech Reports in PRSL's library (500+) cataloged but due to time constraints only the reports written by our branch itself (200+) have been cataloged. The new system provides a better capability to search the library.

A data base that contains a list of all of the tech reports and their abstracts would create a timely and efficient way to access the Branch's cooperate knowledge as contained in the Branch's Tech Reports.

The following pages are the Procedure Manual.

PROCEDURE MANUAL FOR
PERSONAL LIBRARIAN
&
THE ACCESS BASED TR ENTRY SYSTEM

Table of Contents

Introduction/Background

Up until now finding a Tech Report has not been easy. The only way to find a Tech Report that is contained in the Branch Library (300 + Tech Reports) has been to use trial and error, a method which could take hours. Or you had to have previous knowledge of the report and approximately when it was written. A Data Base that contains a list of all of the tech reports and their abstracts would create a timely and efficient way to access the Branch's corporate knowledge as contained in the Branch's Tech Reports. The ultimate goal of the project is to have all of the Tech Reports in the library cataloged but due to time constraints I was only able to get the Reports written by our Branch itself (200+) The new system provides a better capability to search the library.

CHAPTER 1: ADDING A TR (TECH REPORT)

PART 1: Adding a TR Using the Access Based Data Entry System

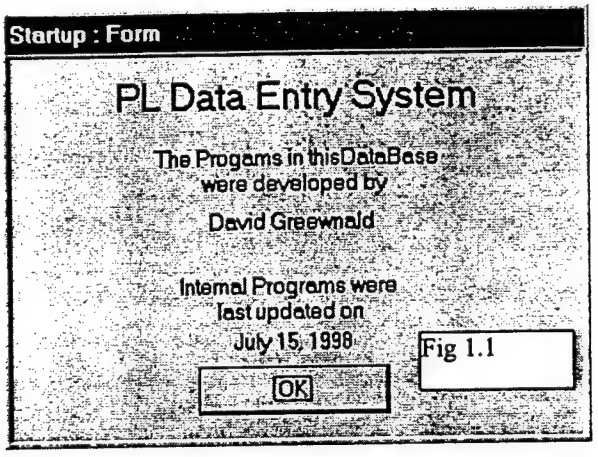


Fig 1.1

First open the PL Data Entry System. When it first starts you will see the window shown in Fig 1.1. Just close it to move on by left you should then be taken to the main editing screen (see Fig. 1.2) where the actual addition of a Tech Report is

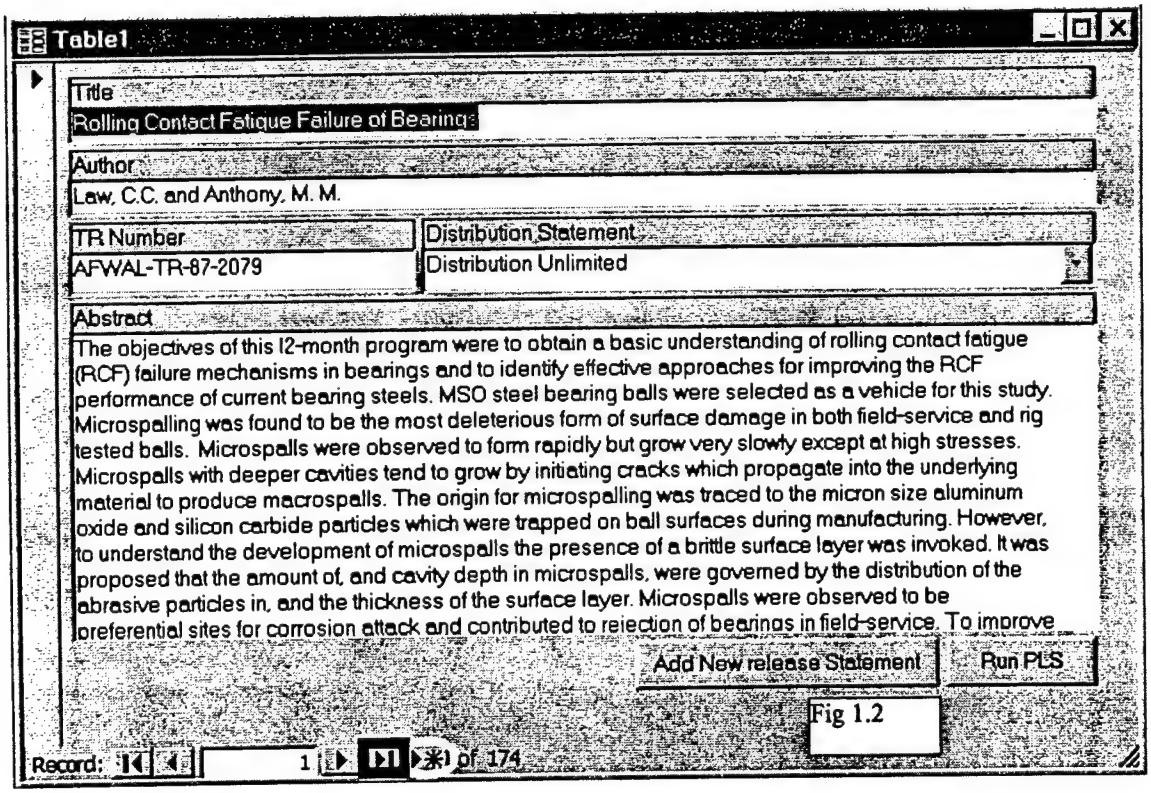


Fig 1.2

done.

To add a TR you must first get to a blank set of fields. To do this you

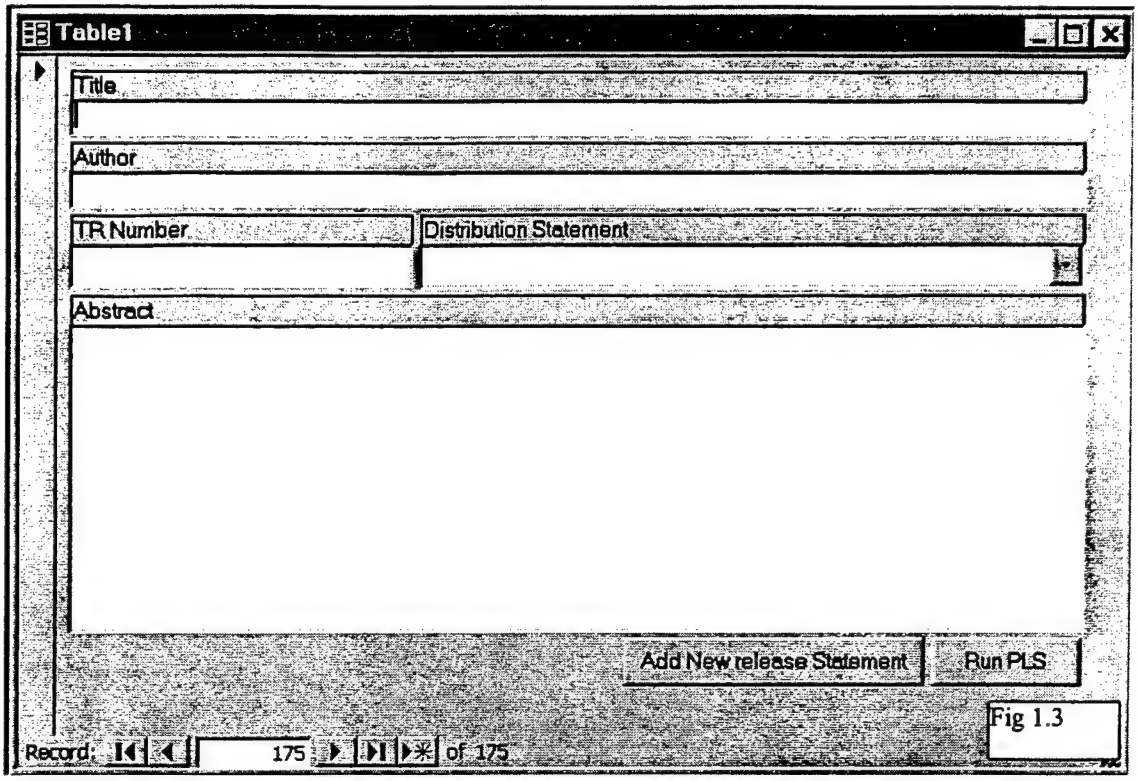


Fig 1.3

vertical line next to it. (See Boxed in Button in Fig 1.2)

PART 3: UPDATING PERSONAL LIBRARIAN

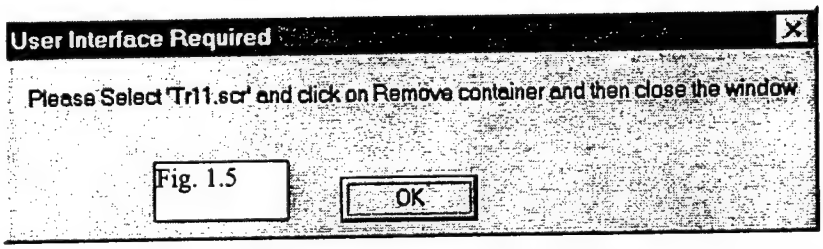


Fig. 1.5

Now that you have added a document into the database you have to update the search engine (Personal Librarian). To do this you first click on the "Update PLS" button (See figure 1.3). You should then get a window that looks like fig. 1.5. This window is there to remind you what to do so that you do not need the manual every time you go to update PLS. Click OK. Now open the Personal Librarian Administration Tool. Click OK on the first window that shows up. You should then have a window that looks like fig 1.6. Click on the area that says "tr11.src" (outlined in yellow in fig. 1.6). Then click on the remove container button (outlined in red in fig. 1.6) and finally on "GO" (outlined in green in fig. 1.6). You

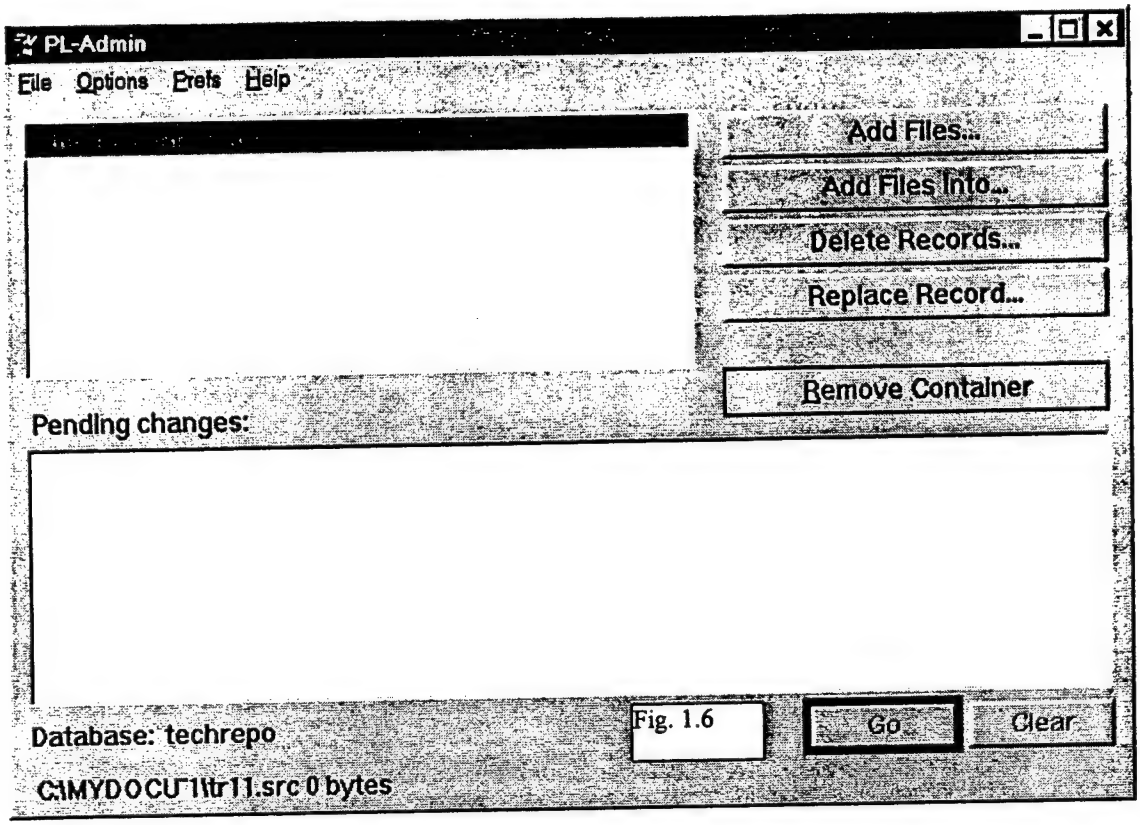


Fig. 1.6

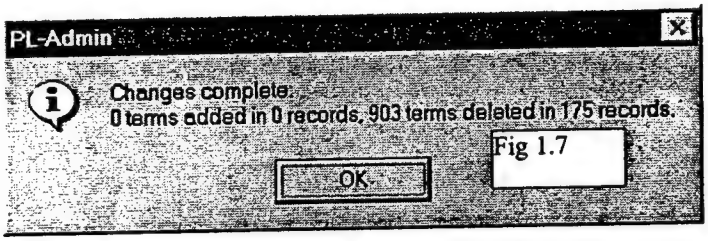


Fig 1.7

should then get a window that informs you what the program is doing. When it is finished you should see a window that looks something like fig 1.7. Click

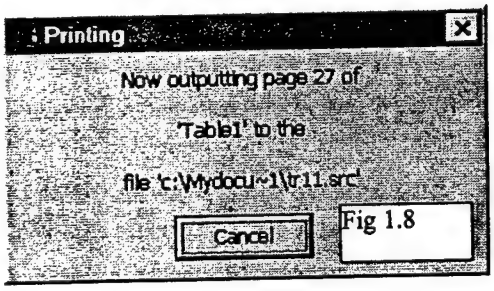
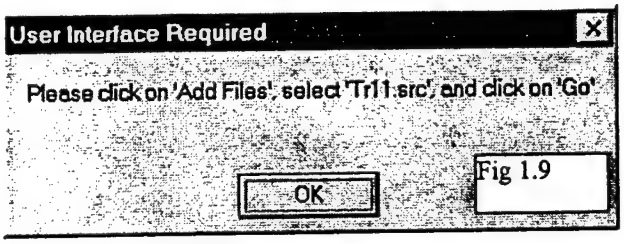
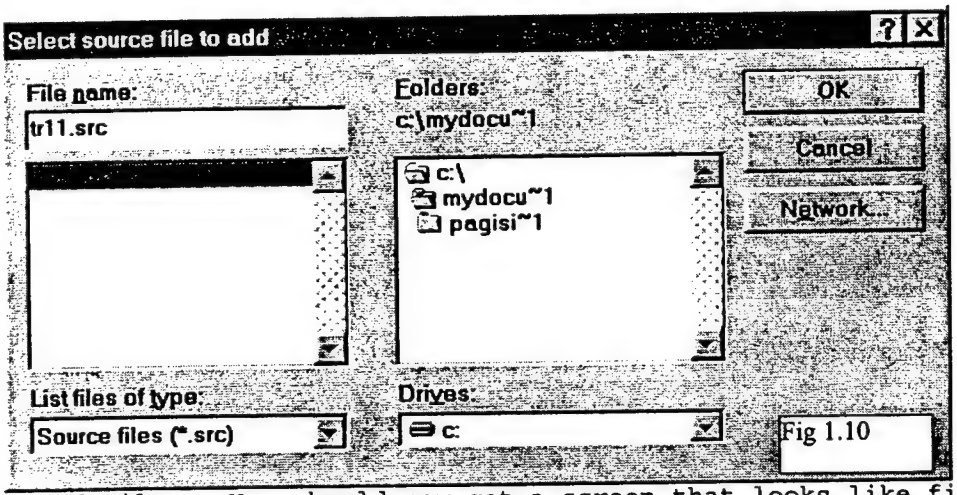
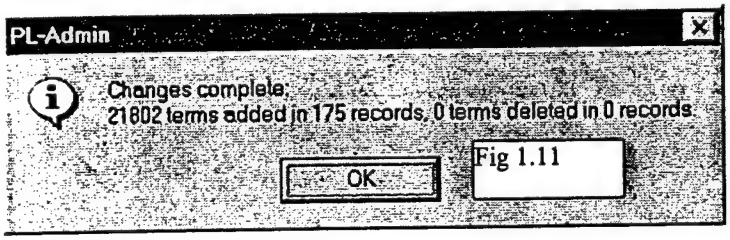


Fig 1.8

OK and return to Access. If access is still printing to a file you will see a window similar to fig 1.8 if not you will see fig 1.9. If access is still printing to a file wait until you see fig 1.9. The window that fig 1.9 looks like is again a reminder of what you are supposed to do. Click "OK" to continue. Go back to PL Admin. You should now see the same window as before. Click on Add Files. You should now get a screen that looks like fig 1.10. Click on tr11.src and click "OK". The window in fig 1.10 should go away. Then click on "GO". You will get a window that shows you what the program is doing when it is finished it will display a window that looks like fig 1.11. Click "OK" and close PL Admin. You have just updated the TR Library database.







Chapter 2: Using PL (Personal Librarian)

Part 1: Using PL

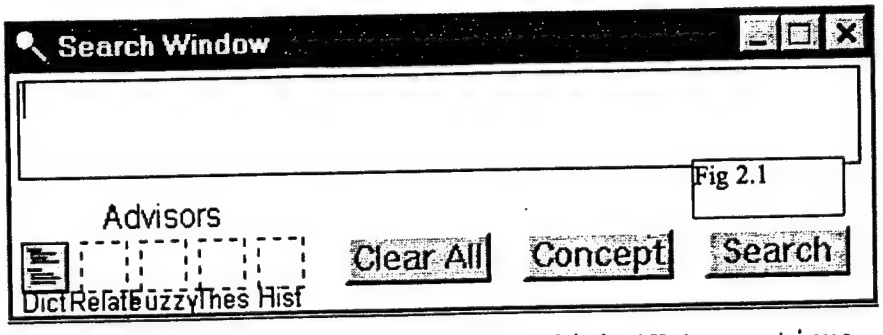


Fig 2.1

When you first open PL (Personal Librarian) you should get a window that tells you about PL. Click OK to continue. You should then get the main search window that looks like fig 2.1. There are four different searches you can use; keyword, fuzzy, concept, and natural language.

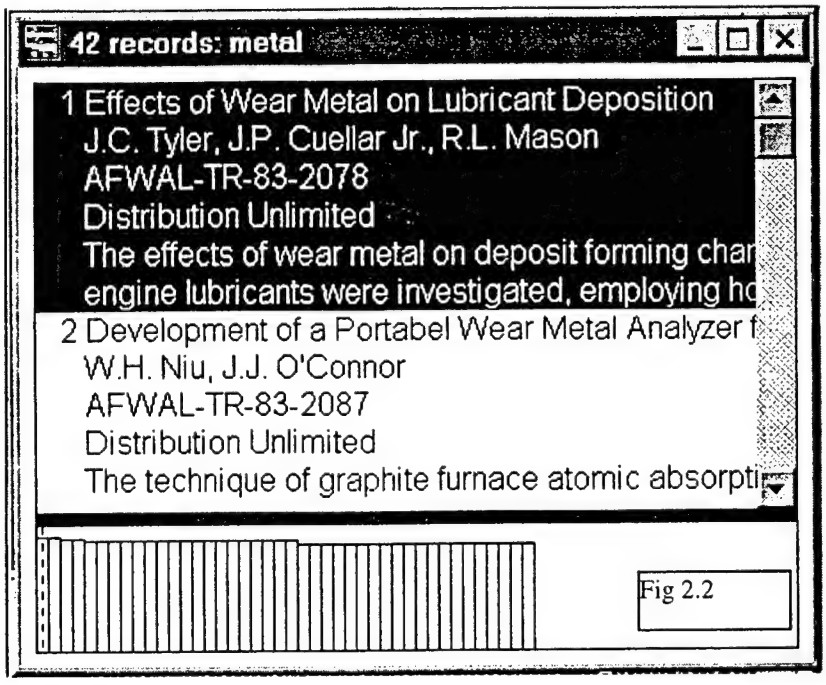
Keyword Search: type your key words into the search window and click on the search window. The keyword search is the search you would use if you were searching for Author, TR Number, etc.

Fuzzy Logic: This is a very important search to use for the reason that there are spelling errors in the database also if you do not know how the word is spelled a Fuzzy search can find it for you. To do a Fuzzy Search type the query into the search field and click on the "Fuzzy" button.

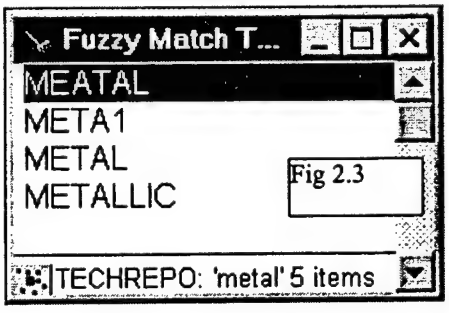
Concept Search: In a concept search the program looks for keywords in the data base then in the entries it finds looks for more keywords. To

do a Concept Search type your query into the search field and click on the Concept Search.

Natural Language: To do a Natural language search just type in you question like you were talking to someone and click on search. Questions like "How do Carbon Carbon bearing keep temperature down" will give reasonably good results.



All of these types of searches will give you the results in a window that looks like fig 2.2 or 2.3. If they look like 2.2 just double click on the Tech Report that you want to read. If they look like 2.3 double click on the word you want to look at the results for and you will get a window like 2.2. To view the rest of the Tech Reports Entry just double click on the entry you want. (You should get a window that looks like fig 2.4



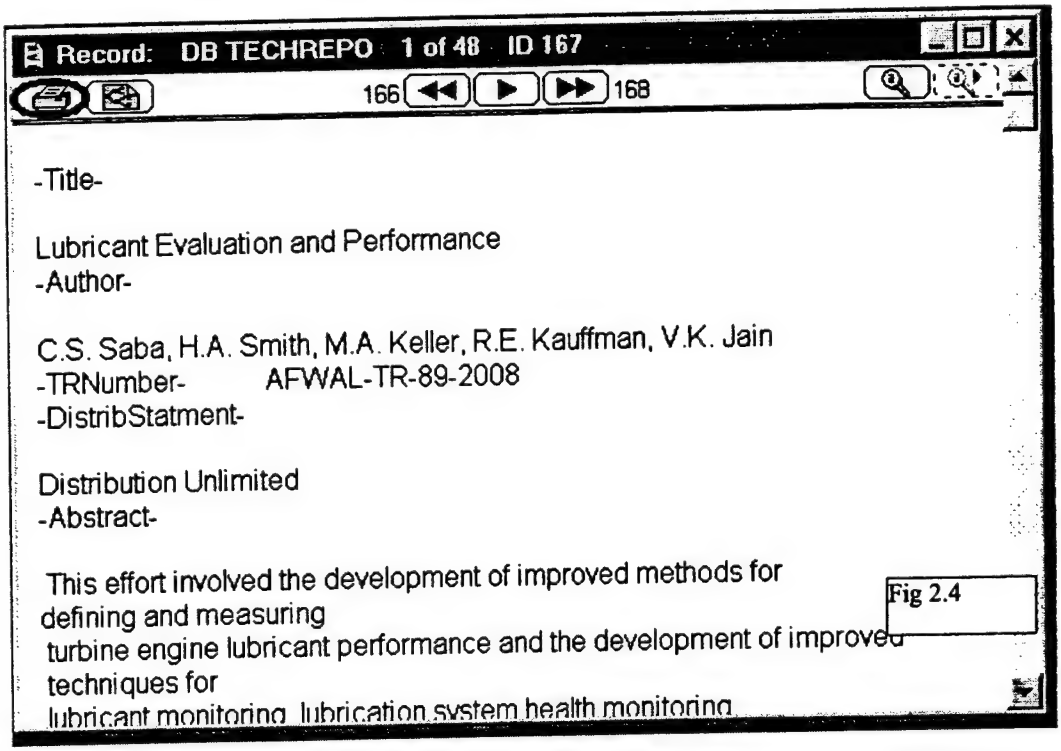


Fig 2.4

The arrows at the top of Fig 2.4 move you from the present TR to the next one or the previous one.

PART 2: Printing

Let's say that you have found a document that you want to print. To so this just open up the Abstract that you want and click on the print button (this has been circled on fig 2.4.)

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This manual was created on 08/18/98 by David Greenwald

Appendix 1: PLS Free Software License

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(Version 1.0)

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THE SYNTHESIS OF MONOMER FOR USE IN WATER-SOLUBLE RIGID-ROD POLYMER SYSTEMS

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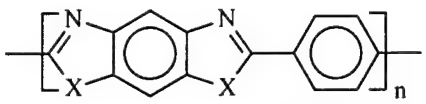
Abstract

2, 5-Disulfoterephthalic acid was synthesized for use as a monomer for elaboration into water-soluble rigid-rod polymer systems. The monomer was synthesized via a four-step methodology. Diethyl 2, 5-dihydroxyterephthalate was converted to 2, 5-dimercaptoterephthalic acid via the formation of the O, O-bisthiocarbamate followed by thermal rearrangement to the corresponding S, S-bisthiocarbamate which was hydrolyzed by alkali to the desired aromatic dithiol dicarboxylic acid after acidification. 2, 5-Dimercaptoterephthalic acid was oxidized to the desired 2, 5-disulfoterephthalic acid monomer using aqueous H_2O_2/HCOOH conditions. All the reactions afforded high yields rendering this a feasible route for the formation and isolation of the desired monomer.

Introduction

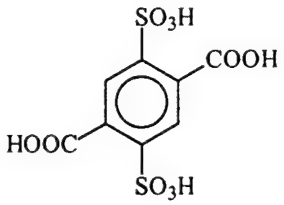
Aromatic heterocyclic rigid-rod polymers (benzobisazole, shown below) are known for their exceptional



X = O, NH, S

mechanical strength and high thermal stability and are thus useful for a number of aerospace structural applications. The major processing difficulty is due to their lack of solubility in most of the known solvents except for highly corrosive strong acids such as polyphosphoric acid or methanesulfonic acid. Recently, it has been demonstrated that the presence of a sulfonic acid pendant in the rigid-rod backbone dramatically alters their solubility characteristics, making them amenable to processing in familiar organic solvents such as alcohol, and polar aprotic solvents such as DMSO and DMAc. This made possible the formation of sol-gel hybrids (ceramers) [1, 2], and thermoplastic and thermoset molecular composites with rigid-rod polymers as reinforcing elements [3, 4].

It has been proposed in the current study that increased sulfonic acid content in the form of sulfonic acid pendants should also facilitate polymer solubility in solvents as common as water. A number of applications have been envisioned for water-soluble rigid-rod and extended-rod polymers. These applications include materials for ionic conductors, fuel cells, high performance organic coatings, and materials with superb compressive strength. The rigid-rod version of these polymers will also be evaluated for electrical conductivity via the formation of self-doped oxidized structures. Accordingly, the objective of this project was the synthesis of monomers with two sulfonic acid substituents as exemplified by 2, 5-disulfoterephthalic acid shown below.



Discussion of Problem

Direct sulfonation of terephthalic acid even under drastic conditions (fuming sulfuric acid and temperatures greater than 250° C) has been found to result in the formation of 2-sulfoterephthalic acid as the major product and further sulfonation does not occur. Direct sulfonation of p-xylene results in different regioisomeric compositions of the disufonic acid in the aromatic ring rendering separation very difficult for further oxidation to the desired monomer. In the current work, the selective oxidation of 2, 5-dimercaptoterephthalic acid was explored for the formation of 2, 5-

disulfoterephthalic acid. Initial efforts in the laboratory were the high-pressure carboxylation of 1, 4-benzenedithiol (commercially available at a very high cost) with carbon dioxide gas in the presence of potassium carbonate[5] (Kolbe-Schmidt conditions). Since the attempt proved unsuccessful, the alternative synthetic methodology that was adopted involved two distinct stages: the first stage involved the formation of 2, 5-dimercaptoterephthalic acid via the literature route[6] with diethyl 2, 5-dihydroxyterephthalate as the starting material; this was followed by the oxidation of the thiophenol function to the sulfonic acid function.

Methodology

The synthetic scheme for the above objective is given in figure 1 below.

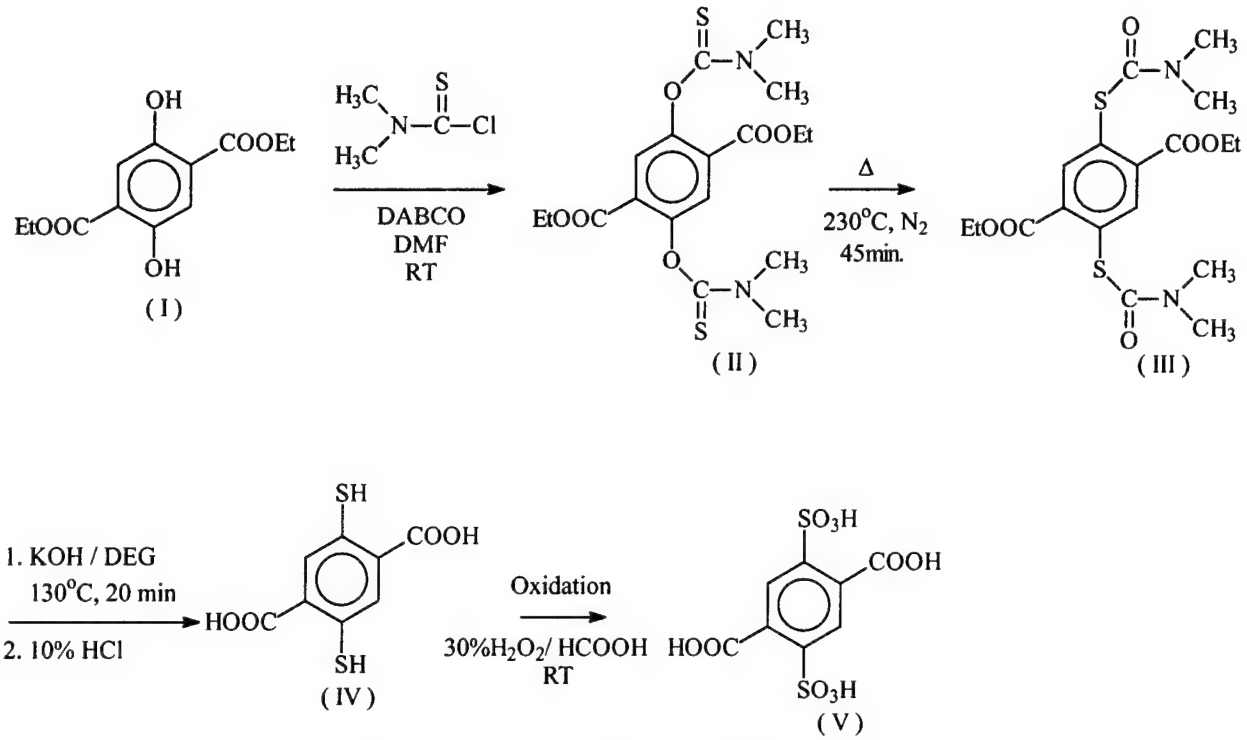


Figure 1 Scheme for Synthesis of 2, 5-Disulfoterphthalic acid

Preparation of 1, 4-O, O-2, 5-Bis (ethoxycarbonyl) phenylene Bis (N, N-dimethylthiocarbamate) (II):

5.1 g of diethyl 2, 5-dihydroxyterephthalate and 13.5 g of DABCO were dissolved in 90 ml of DMF in a three-neck flask equipped with stirring and a nitrogen atmosphere. To this solution was added 14.8 g of N, N-dimethylthiocarbamoyl chloride and the reaction proceeded as such at room temperature for three hours. The product precipitated as a white solid, which was frit filtered and washed with water in order to remove traces of DMF. The reaction afforded 7.5 g of product (92 percent yield) with a melting point of 211 – 213° C, allowing for further

synthesis without recrystallization.

Preparation of 1, 4-S, S-2, 5-Bis (ethoxycarbonyl) phenylene Bis (N, N-dimethylthiocarbamate) (III):

7.5 g of (II) were taken in a polymerization flask fitted with a mechanical stirrer and a nitrogen atmosphere inlet; the flask was then heated to an oil bath temperature of 240° C and allowed to react for 45 minutes. The resulting product was a brown solid collected in overall yields of 92 percent (6.9 g). The product was then recrystallized from toluene resulting in off-white crystals with a sharp melting point of 143 - 144° C (4.46 g collected, 60 percent yield).

Preparation of 2, 5-dimercaptoterephthalic acid (IV):

A 100 ml (1.74N) solution of potassium hydroxide (9.74g, 85 percent KOH) in diethylene glycol was prepared of which 26.9 ml were placed in a three-neck flask, equipped with stirring and a nitrogen atmosphere inlet. The reaction mixture was heated to 130° C. Upon reaching the target temperature, 2.5 g of (III) were added to the solution and allowed to react for twenty minutes. The reaction was then cooled to room temperature and diluted with 269 ml of water. After dilution, the solution was acidified with 10 percent HCl to precipitate a yellow solid; the process was continued until the supernatant was mildly acidic. The suspension was frit filtered under a nitrogen atmosphere and washed with water to remove traces of acid. The compound collected, (1.16 g, yield 85 percent) decomposed at 357° C.

Preparation of 2, 5-disulfoterephthalic Acid (V):

0.5g of (V) were taken in a round-bottom flask and stirred with 30 ml of formic acid to form a yellow suspension. To that was added 12ml (30 percent) hydrogen peroxide. An exothermic reaction took place resulting in a clear solution. The solvents were removed by rotovap to isolate the product with a yield of 81 percent (0.57g). The compound was found to darken and decompose at 255° C.

Results

The overall conversion of diethyl 2, 5-dihydroxyterephthalate to the desired monomer, 2, 5-disulfoterephthalic acid, was accomplished in satisfactory yields, making this scheme feasible for further scale-up and optimization. The published literature procedure for the synthesis of the intermediate (2, 5-dimercaptoterephthalic acid from diethyl 2, 5-dihydroxyterephthalate)[6] was followed with minor modifications. A significant improvement was obtained in both yield and purity for the product of the thermal rearrangement (III). Slightly higher temperatures and longer reaction times furnished the product with a much narrower melting point than reported in the literature. The oxidation of thiophenol to sulfonic acid was carried out in 30 percent hydrogen peroxide and formic acid. Since the reaction was quite exothermic, much care was exercised during the scale-up of this reaction. The crude

monomer was recrystallized from concentrated HCl. Microanalytical results of a vacuum dried sample showed an elemental composition (C, H, S) that corresponded to a disulfonic acid dihydrate [$(SO_3H{\cdot}H_2O)_2$] rather than the anhydrous structure.

All the compounds synthesized were characterized by FT-IR and mass spectrum. Figure 2 shows the composite IR spectra of the compounds (II, III, and IV). Compound (II) shows at 1715 cm^{-1} a carbonyl frequency characteristic of the ester group and a thiocarbonyl (C=S) frequency due to N, N-dimethylthiocarbamate group at 1544 cm^{-1}. The product of thermal rearrangement, (III) shows an ester carbonyl at 1718 cm^{-1} and an N, N-dimethylthiocarbamate carbonyl at 1674 cm^{-1}. There is total disappearance of the of the IR band at 1544 cm^{-1} in the rearranged product. The IR of compound (IV) shows a weak SH band characteristic of thiophenol at 2554 cm^{-1}; also seen are a broad OH band due to the carboxylic acid in the 3500-2500 cm^{-1} range and a hydrogen bonded carbonyl of the carboxylic acid group at 1687 cm^{-1}. (Figure 3) shows a comparative IR plot of 2, 5-dimercaptoterephthalic acid and 2, 5-disulfoterephthalic acid. It is evident from the spectrum that complete oxidation of the thiol has taken place. A broad hydroxyl band in the 3600-2300 cm^{-1} range is present due to the sulfonic and carboxylic acid substituents. The carbonyl of the carboxylic acid appears at 1708 cm^{-1}. The SO_2 stretch due to the hydrated sulfonic acid appears as a multiple band in the range 1230-1110 cm^{-1}.

Figure 4 shows the mass spectrum of compound (IV), the M^+ appears at m/z = 230; major fragment ions occurred due to successive losses caused by the elimination of water from the parent ion (m/z = 212, 194). Figure 5 shows the mass spectrum of compound (IV), the desired monomer. Under the conditions of mass spectrum the molecular ion (m/z = 290)that is observed is due to the bisanhydride structure as shown in the figure. The structure arises from the loss of two molecules of water from 2, 5-disulfoterephthalic acid.

Conclusions

A viable oxidation route for the synthesis of 2, 5-disulfoterphthalic acid from the corresponding dithiol has been devised. 2, 5-Dimercaptoterephthalic acid was prepared in high yields via a literature route. Further optimization and scale-up showed that the desired monomer could be prepared in overall high yields using this methodology.

Acknowledgements

The opportunity provided to me by Dr. Fred E. Arnold and Dr. Robert C. Evers, Polymer Branch Wright Patterson Air Force Base, for my participation in the HSAP program is greatly appreciated. Thanks are due to Dr. N. Venkatasubramanian for his guidance and supervision throughout the tenure of this project. Appreciation is also extended to Mr. Thuy D. Dang for his keen interest and helpful technical discussions.

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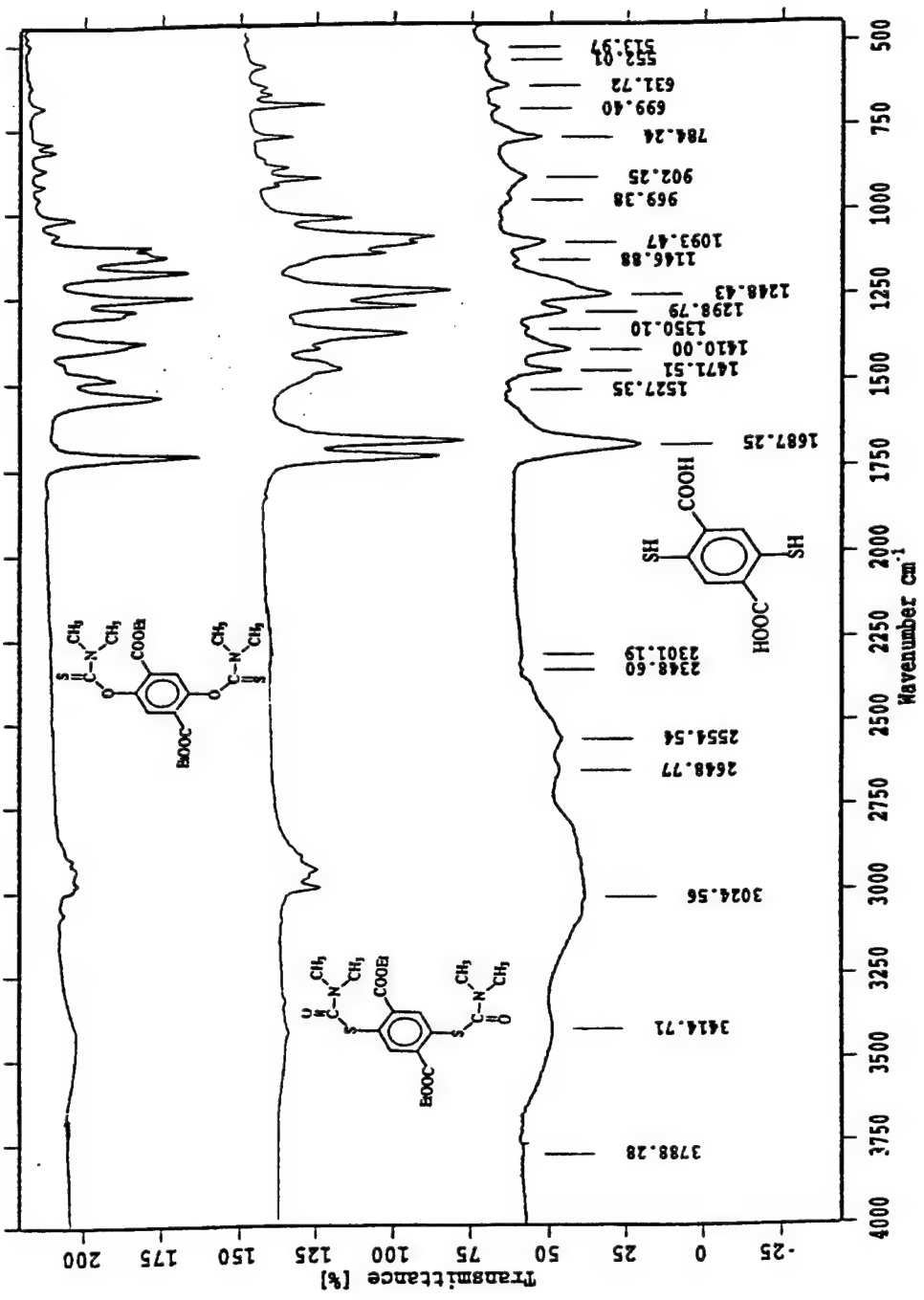

Figure 2. The Composite IR Spectra of Compounds (II, III, and IV)

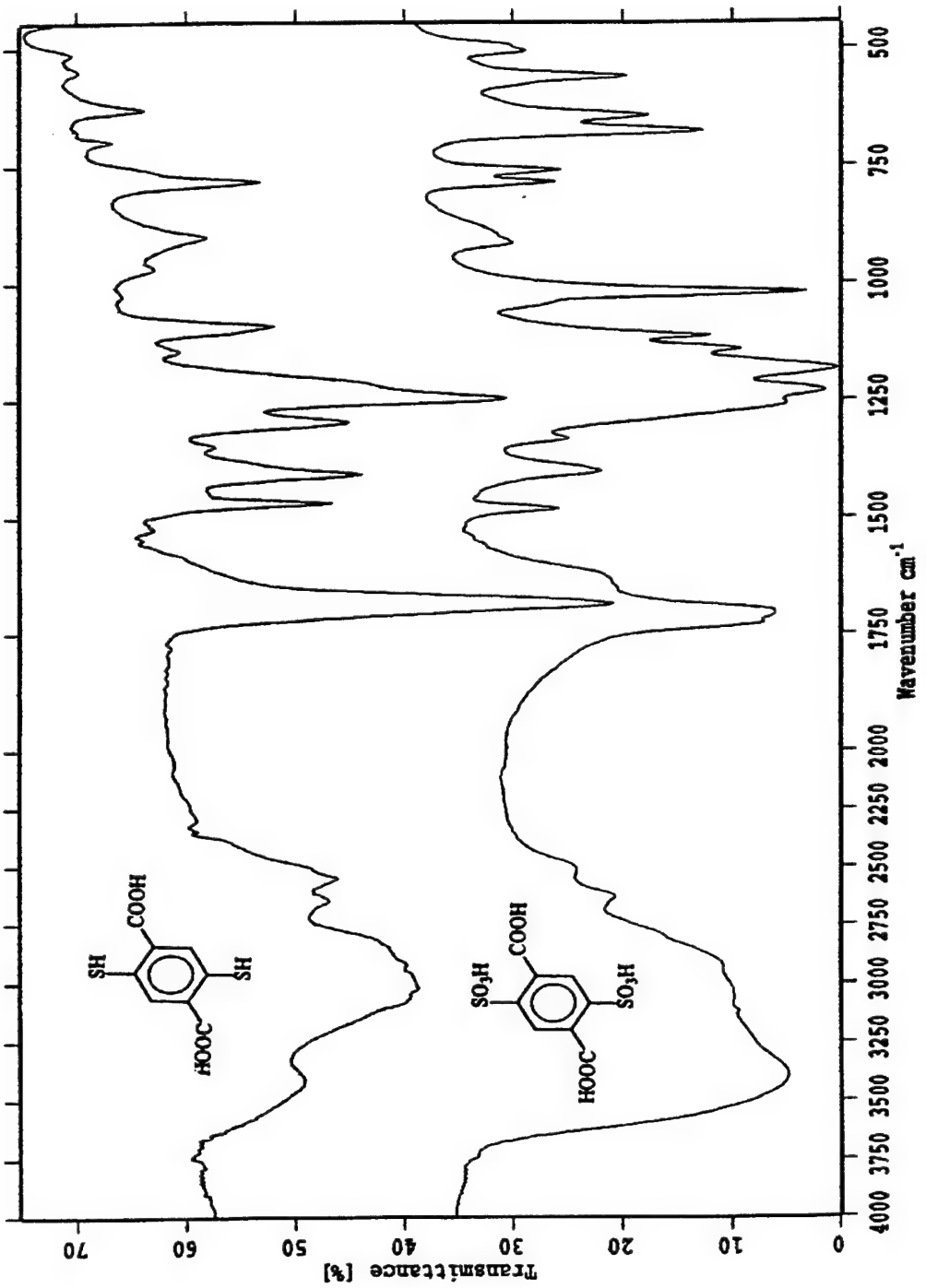

Figure 3. The Composite IR Spectra of Compounds (IV, and V)

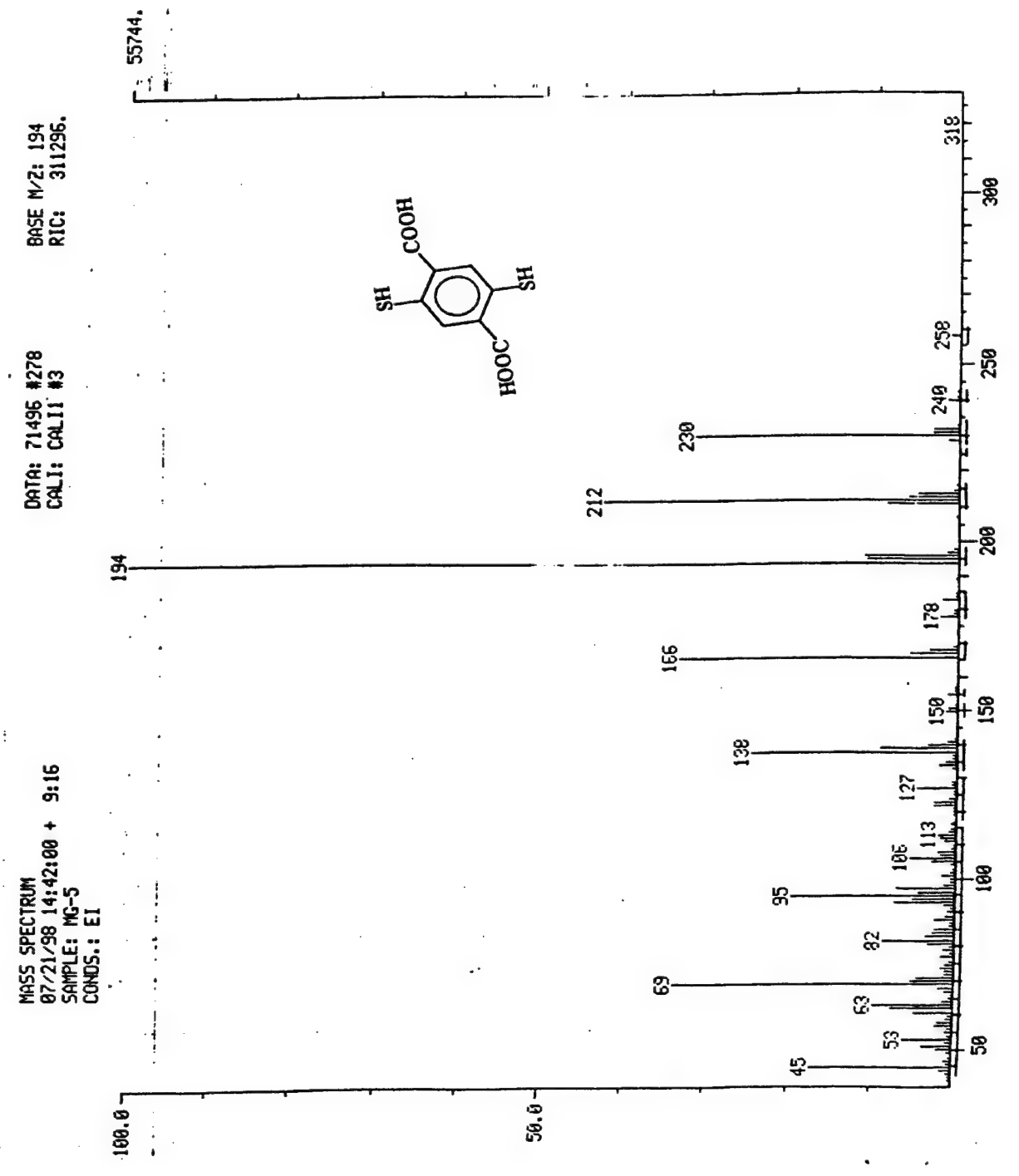

Figure 4. The Mass Spectrum of Compound (IV)

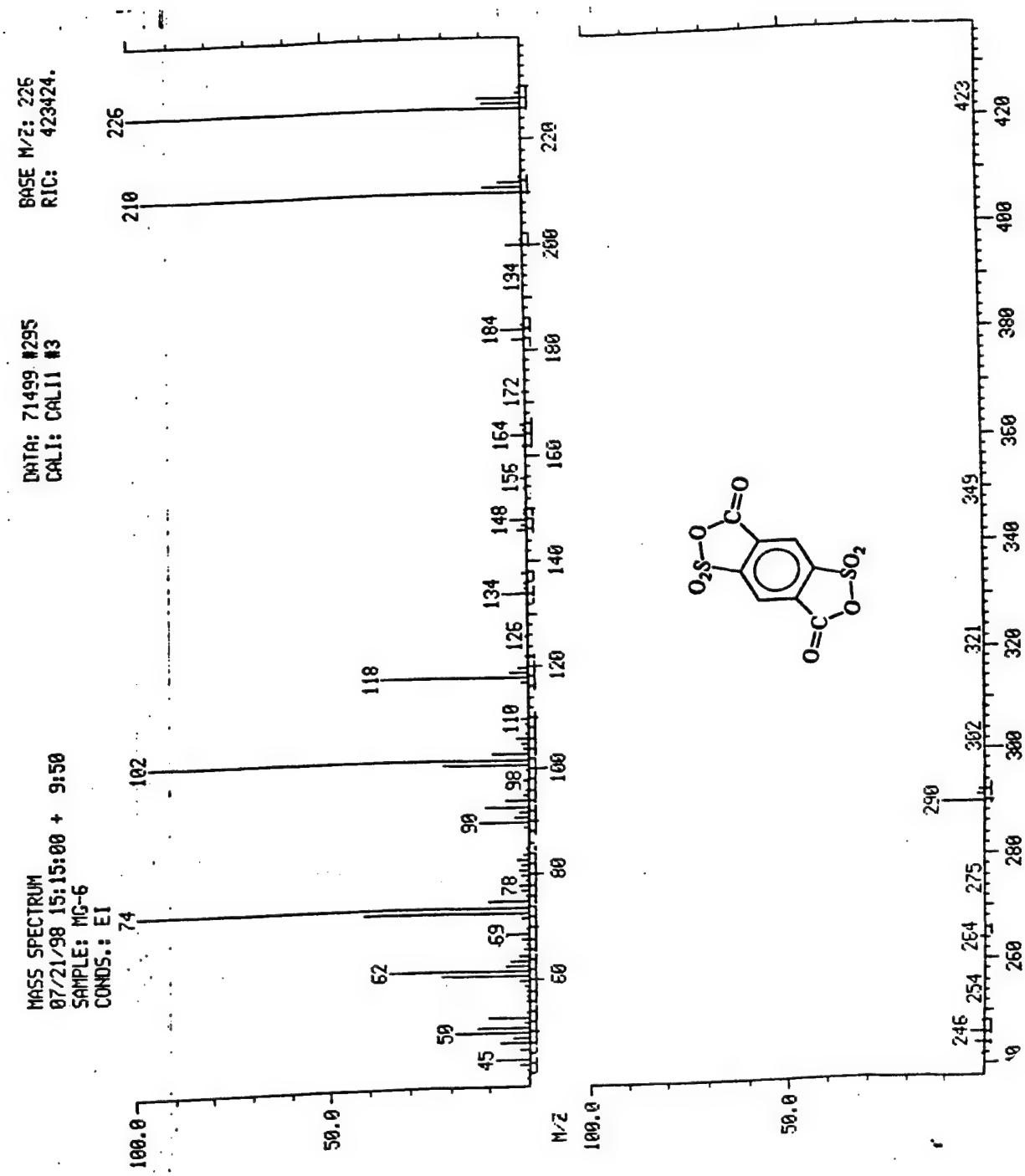

Figure 5. The Mass Spectrum of Compound (V)

HIGH DENSITY POLY-ETHYLENE "WAFFLE" LINER STUDY

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Final Report for:
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Sponsored by:
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And

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Abstract

In the increasing effort to improve warhead characteristics, the concept of fragmentation control has become an important issue. Conceptually, this technique would be capable of producing a high percent of a specified sized fragment at any given time. This enhances the warhead fragment effectiveness by twofold. Initially, it would help by cutting the large, bulky fragments into more fragments of a medium size. Secondly, it will amplify the performance of the warhead by converting many of the abundance of small fragments into larger, more usable fragments. In this study, a computer simulation using a Hull hydrocode was accomplished followed by sub-scale testing to determine the effectiveness of a High Density Polyethylene (HDPE) warhead case liner. In the fabrication of this liner, a HDPE sheet of specific thickness (τ) is cut into a "waffle" pattern, containing numerous staggered diamond cuts. Variance of the diamond incident angle (ϕ), band length (λ), and band width (β) allow for specified size case fracturing and should optimize the capability of controlling fragmentation. Fragmentation results indicate initial success in controlling case fracture.

HIGH DENSITY POLY-ETHYLENE "WAFFLE" LINER STUDY

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Rocky Bayou Christian Academy

Introduction

To advance military technology to the Twenty-first century, programs have been established to enhance the capability of warheads. Multiple concepts exist which increase warhead effectiveness. These include explosive enhancements, beam spray control, multi-point initiation schemes, and fragmentation control. This study focused on the development of a plastic liner designed to control the fragmentation of warhead cases.

Controlled fragmentation is the mechanical alteration of warhead case fracture during the detonation event targeted specifically to produce uniform fragments in a narrow sized band width. In other words, at any given time, a high percent of a specific size fragment can be produced. This enhancement is characterized by generating more usable fragments presentable to the target. A "natural" case break-up (without design influences) will yield thousands of small fragments (0-100 grains). It will also produce some extremely large fragments which are ineffective because they cover only a small area. The controlled fragmentation effort is designed to manipulate the case fracture to force many of these small and large fragments into more usable fragments which are more effective against designated targets.

The mission of this study was to develop a low cost method to control fragment size (or weight) while retaining case wall structural integrity. It was approached using a Hull hydrocode analysis (computer simulation) followed by sub-scale testing. The hydrodynamic analysis provided a quick look at the effectiveness of the liner while the sub-scale testing provided real effectiveness data.

Background

Over the past thirty years, multiple concepts have been developed to control case break-up. Examples of these techniques include scored case walls, pre-formed fragments, and staggered V-groove liners. The first concept, scored case wall, involves imprinting a specific pattern on the inside of the warhead case.[1] Upon detonation, this pattern causes increased pressure points leading to mach stem formation. The scored pattern is followed in the fragmentation. This method has proven effective; however, the high cost to score the case wall coupled with diminished structural integrity made this a less than desirable approach. Expanding the concept, pre-formed fragments offer another capability. Pre-formed fragments are fused to an inner case, which resides inside the

primary case wall. During detonation, the increased pressure on the pre-formed fragments cause similar rupture to the primary case. This method is also proven, although its application is limited to thin cases. This method typically requires specialized explosive loading techniques.

In the late 1960's, the first plastic case liner concept was researched.[2] Primary interest during that time focused on the development of a staggered V-groove liner. This liner is a piece of plastic with 'V' shaped wedges pointing away from (perpendicular to) the case wall The 'V' forms a void in the explosive. Upon detonation, these voids produce high pressures along the walls of the 'V'. When these pressure waves combine, they form mach stems, which in turn punch a hole in the case wall. The staggered design of the lines creates four points, which, during case expansion, serve as vertices of fragments. This concept is extremely effective, although it has its negative aspects. First, for this method to be effective, the depth of the V-groove must be at least 1:1 with the case wall thickness. For any case wall greater than 1/2", the liner volume becomes substantial. Secondly, the cost of the mold to create the liner is high. Usability of this method is typically limited to one V-groove design.

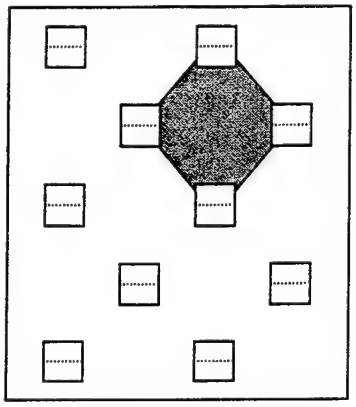

Figure 1: Staggered V-groove liner (side view)

Figure 2: Staggered V-groove liner (top view)

In the same study, the concept of a thin plastic "waffle" liner was introduced. However, the researchers recognized some difficulty of explosive loading using this liner and eliminated it from the study. In the use of this liner, it is imperative that the liner makes full contact with the case wall. Even the smallest amount of separation quickly reduces the effectiveness. The current study has eliminated this problem and solely concentrates on developing this liner. This method does comply with the mission goals of providing a low cost method to control case fracture while still retaining structural integrity.

"Waffle" Liner Conceptual Design

Hydrodynamic Analysis

Before any actual testing was accomplished, a computer simulation using Hull hydrocode was performed in order to test theoretical capabilities. The hydrocode included simulated explosive, mesh liner, and 4340 steel case wall (Figure 3).

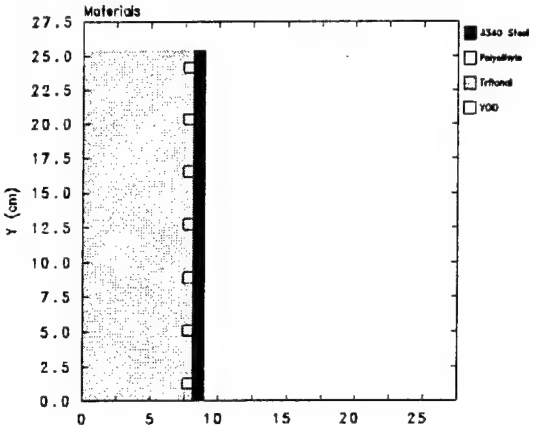

Figure 3: Hydrodynamic analysis

Top initiating, the detonation wave propagates down through the explosive, expanding the case wall (Figure 4). Upon reaching the nodules, or simulated waffle liner, there is an instantaneous pressure build up. This is analogous to placing a rock in moving water. If a rock is placed in a stream, there will be a region of higher pressure on the upstream side of the rock. The rock will also divert the flow of water. In the case of the liner, the increased pressure causes a mach stem effect on the incident side of the liner (nodule). As the case expands beyond its tensile strength, it begins to fracture (Figure 5). In a "natural" case, this typically occurs at 1.5 to 2 times the diameter. With the manipulation of the pressure wave by the liner, the case is forced to fracture along the lines of higher pressure. In this stage of the detonation, the liner is disintegrated. Upon complete fragmentation (Figure 6), the pressure wave has progressed through the case wall, causing some secondary fragmentation. In a "natural" detonation, an abundance of smaller fragments are created. With the "waffle" liner, the effort is to reduce the number of small fragments, forcing them into larger, more usable fragments. However, at this stage of development, secondary fragmentation still exists. Success for this initial study will be based on increased production of fragments in the specified weight region.

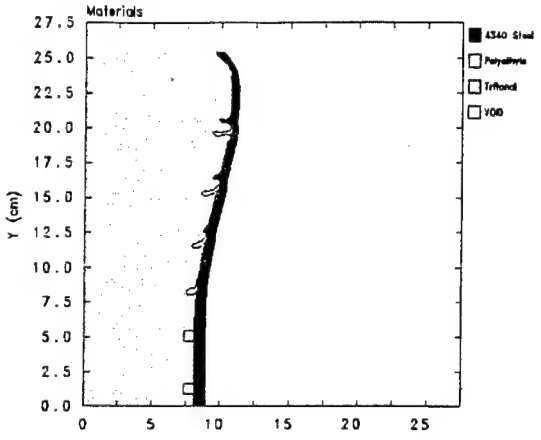

Figure 4: Hydrodynamic analysis

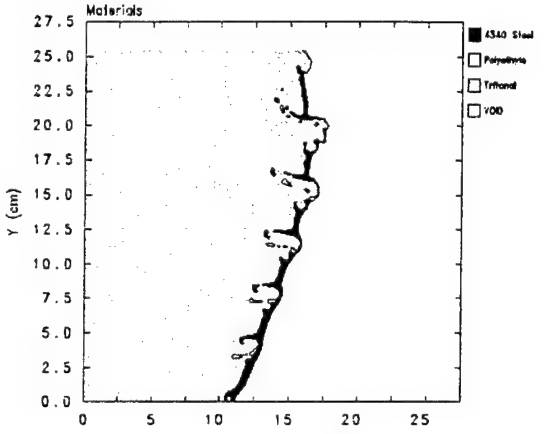

Figure 5: Hydrodynamic analysis

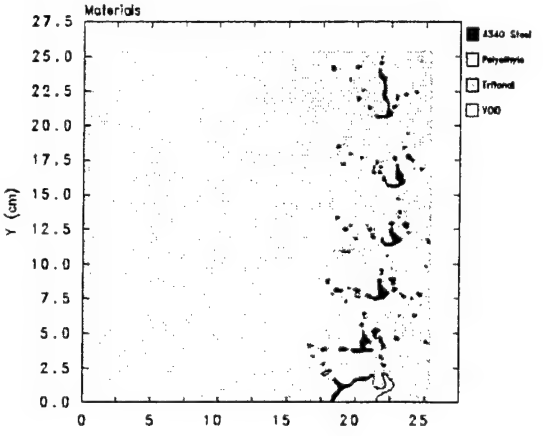

Figure 6: Hydrodynamic analysis

High Density Poly-Ethylene "Waffle" Liner Design

The "waffle" liner is composed of High Density Polyethylene (HDPE), or a form of plastic.[3] Beginning with a solid sheet of HDPE of a specific thickness (τ), the waffle design is formed by cutting out staggered diamond with a precise incident angle (ϕ). This process is performed by a water jet at AFRL/MNMI's Model Shop. The diamond voids are separated by thin HDPE bands of particular band length (λ) and width (β). The variance of τ, ϕ, λ, and β allow for functions of varying fragment sizes. The HDPE "waffle" liner is rolled and fitted to the internal wall of the case. Initial testing was accomplished using only the liner placed inside the case. These tests proved unsuccessful. The conclusion was that the explosive, when poured, filled between the liner and the case wall. As complete liner contact with the case wall is mandatory, this greatly reduced the effect of the liner. That is, as the detonation wave progressed downward, the explosive between the liner and the case wall reacted, erasing the void necessary to create a mach stem. This led to a random fragmentation. Two possible resolutions to the problem existed. First, the explosive could be loaded via split mold in the presence of the liner. Once solidified, high explosive (HE) formed outside the liner could be cut away. The HE and liner would then be loaded into the case. The second method, and the approach used in this study, is to create a secondary liner to separate the explosive and liner (Figure 7). This was accomplished using 1/32" Ultem. This thin plastic secluded the explosive, keeping it from filling between the liner and case wall. As the detonation wave propagates, the Ultem disintegrates, allowing the explosive to fill the diamond voids.

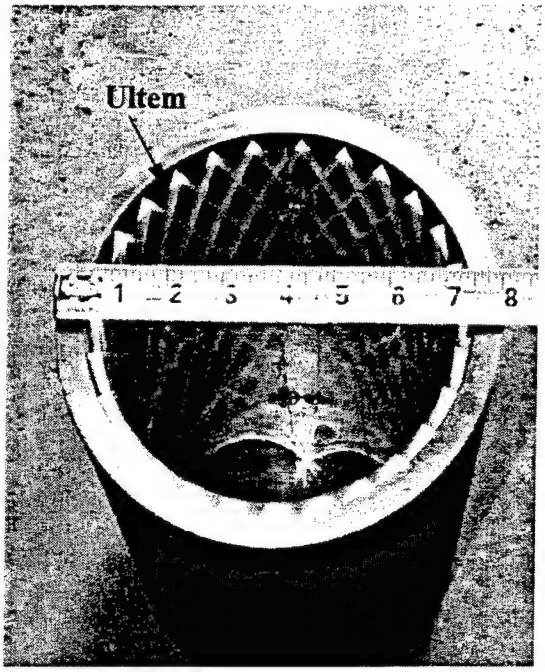

Figure 7: Test item with "Waffle" Liner and Ultem

Fragmentation Test

Test Item Specifications

In this study, a design of experiments approach was used. Instead of testing every possible variable combination, a single variable was altered per test, effectively identifying problem variables. This reduced possible test combinations from thirty-two to seven. In all, seven tests were accomplished along with a baseline test. The baseline is a case minus the liner; its purpose is to provide a "natural," or random, case break-up with which to

Shot #	T (in)	M	β (in)	λ (in)	ϕ (°)	Predicted # Diamonds	Predicted Diamond Weight
1	0.625	4340	1/8	0.950	45	215	600
2	0.500	1020	1/16	0.950	45	292	600
3	0.500	1020	1/16	0.475	45	1040	250
4	0.500	1020	1/8	1.350	30	153	600
5	0.500	1020	1/8	0.750	60	329	600
6	0.500	1020	1/8	1.900	45	65	1200
7	0.500	4340	1/8	0.950	45	245	600

Table 1: Test item specifications

compare the test results. Case 1 emulates a Miniature Munition Technology warhead, and should elicit the effect of small case diameters. Shots 2-6 and the baseline were manufactured of mild tempered steel (1020). Because of this, the comparisons made in this study are all measure against a 1020 steel case. Shot 7 should identify the impact of case material on the fracture control. The goal of this test is to determine the most effective liner dimensions, and conduct further testing to maximize the case fracture control.

Test Platform

Testing was conducted at AFRL/MNMW (range C-64A). Previous collection methods used Celotex bundles to collect the fragments. However, the Sand Recovery Fragmentation Test (SRFT), which has been demonstrated to provide maximum fragment collection at a fraction of the cost of Celotex arenas, was employed. It has a 360° collection angle; this allows for complete data gathering. It is composed of a plywood box with a Sonotube test chamber centrally located within the box (Figure 8). Sand fills the space between the test chamber

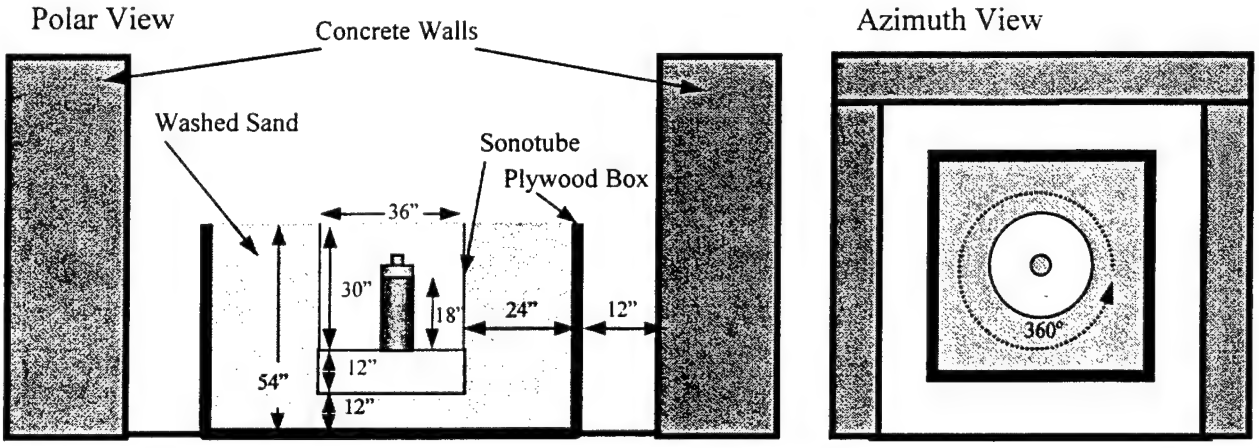

Figure 8: Test Platform: Sand Recovery Fragmentation Test (SRFT)

and the plywood box. The sand serves to decelerate and catch the fragments. The air filled Sonotube provides a chamber for natural case expansion. Only minimal secondary fragmentation is assumed when fragments contact the

sand. Post shot fragment collection is accomplished by a crude sifter box designed to collect fragments greater than 10 grains. This collection method is very efficient, collecting between 85-95% of the test item case weight per shot.

Fragmentation Data Analysis

Once collected, the fragments were weighed by C-64 personnel. A fragment weight database is provided to the test engineer. The initial data reduction consisted of a five step process. Initially, the fragments were sorted into 25 grain categories, creating a plot of # of fragments per Δ mass (ΔM). From the ΔM, statistics were then derived such as average fragment mass, total mass, total number, percent recovery, etc. Next, the data from the baseline shot was fit using the Mott Distribution Equation. This will be discussed in further detail later in this paper. Once the baseline Mott Curve was established, the test data was plotted against the baseline Mott to determine the effectiveness of each test shot.

Secondary data reduction was then performed. First, the fragments were sorted into four categories according to their size and shape. The "Diamond" category contained fragments which appeared to have a diamond shape. The remaining fragments were then sorted into the following three size allocations: "Small": comprised of fragments weighing less than 200 grains; "Medium": between 200 and 800 grains; and "Large": fragments greater than 800 grains. The fragments in the "diamond" category were then re-weighed and plotted against the total fragment weights. This allowed for a glimpse of the "diamond" fragment results. If the test acted according to predictions, the diamonds would exist within a narrow size band width, increasing the number of fragments in that ΔM category.

Mott Distribution Equation

The Mott Distribution Equation gives the theoretical fragment distribution for naturally fragmenting cases. In other words, for naturally fragmenting cases, it yields how many fragments of each weight will be produced from a given case. The mass distribution of the fragments is described by:

[$N(m) = N_o e^{-(m/\mu)^{1/2}}$

Where:

$N(m)$ = number of fragments of mass greater than (m)

N_o = total number of fragments ($M/2\mu$)

2μ = arithmetic average mass

M = total mass of the warhead

And:

$$\mu^{1/2} = B\, t^{5/6}\, d_i^{1/3}\, (1 + t/d_i)$$

Where:

μ is in grams

B depends upon the explosive composition and the physical characteristics of the casing material

d_i = inside diameter of the case

t = case wall thickness]^4

The data collected from the baseline shot was fit using the Mott equation (Figure 9). Since no control methods had been applied, the Mott Distribution should closely resemble the real data. Two important points to notice concerning the data outcome are the sudden increase at the 1000 grain category and the drop off of the actual data in

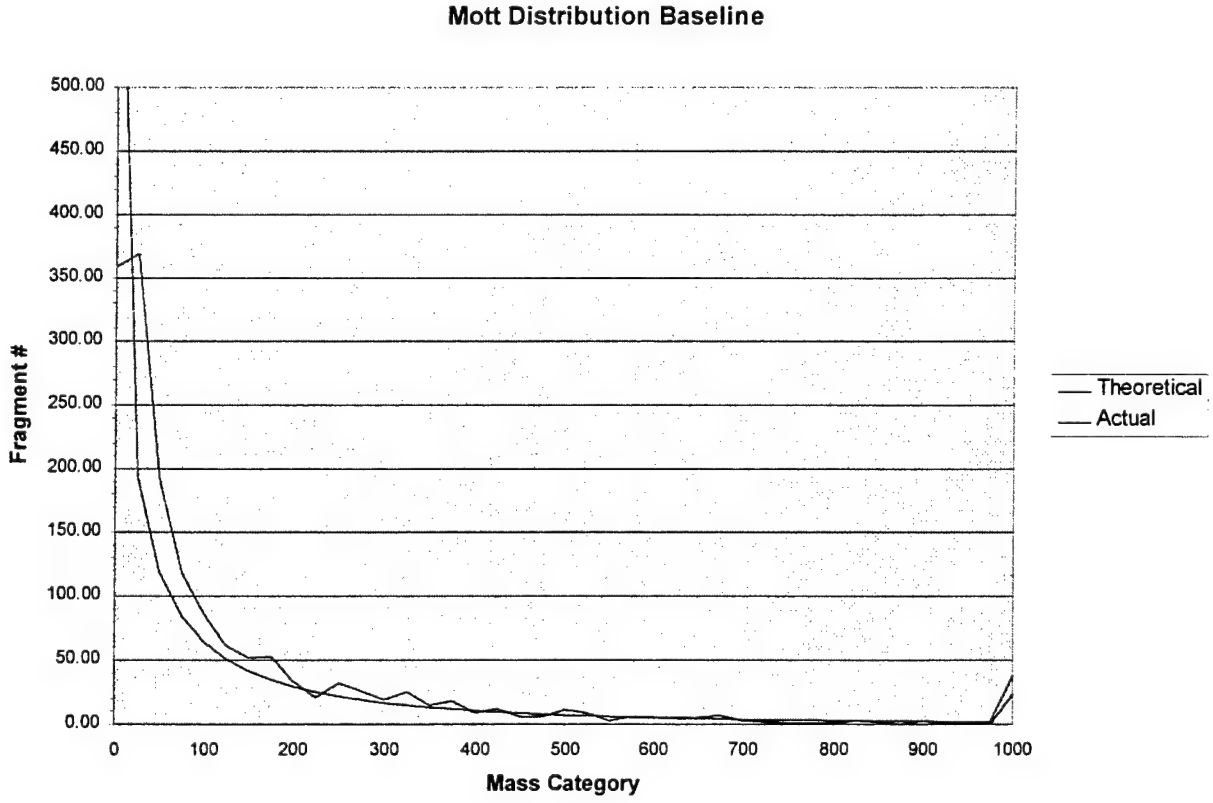

Figure 9: Baseline vs. Baseline Mott

the 0-25 grain region. The rise at the 1000 grain region is due to a sum of the total number of fragments greater than 1000 grains. All previous ΔMs are in 25 grain increments. Second, the drop off of the actual data in the 0-25 grain

region should be noted. When dealing with fragments that weigh less than 25 grains, it is extremely difficult to have a high rate of recovery. Approaching this "dust" region, collecting the fragments is very difficult. Therefore, fragments in this region (0-25 grains) are not considered in the analysis.

Fragmentation Results

In every shot, the diamond shape was found in a significant number of fragments (Figure 10). Since the liner contained exact diamonds, the fragments were expected to be a pure diamond shape. However, at cursory glance, the fragments appeared to be abnormally formed. Many of the fragments contained "wings," attachments along the sides of the diamond. It was then realized that the size/shape of the fragments was a function of the liner dimensions and the thickness of the case wall. The pictures shown here are a two dimensional representation of a three dimensional object. The "wings" are merely the back side (extra mass) of the previous fragment's diamond. Once this was understood, the wings became expected.

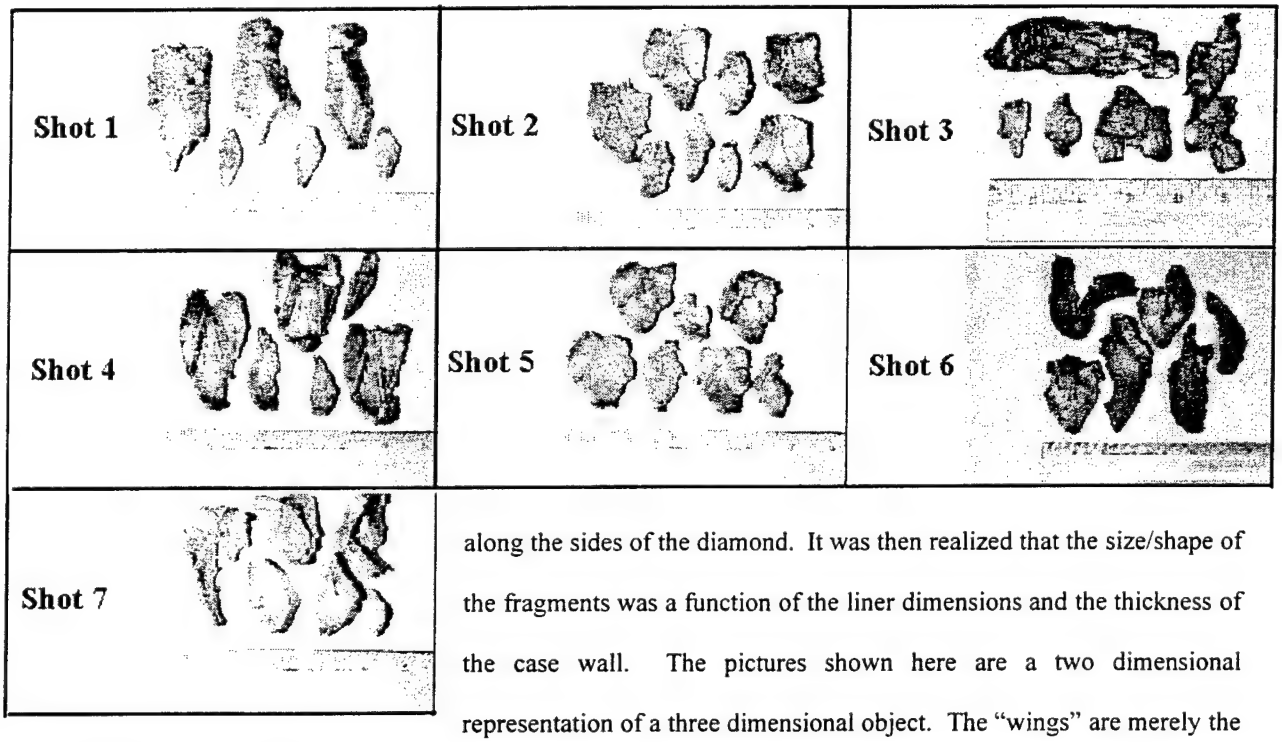

Figure 10: Fragment examples

Most of the tests performed as predicted. However, there were two tests with abnormal fragmentation. Shot 3 was expected to produce 250 grain fragments. This means the liner should have cut fragments which would normally have remained as larger fragments into smaller ones. This was the general case, although many of the larger fragments did not completely break up. In those that remained as large fragments, the diamond cut was clearly observed. The partialness of the cut allowed the larger fragments to remain intact. Had there been complete fragmenting along the liner bands, the results for that shot would have shown an even greater improvement. The

other unexpected result came from Shot 6. This test contained the liner designed to generate 1200 grain fragments. Because the band length was so large, there was much secondary fragmentation within the cut diamonds. Although the diamond shape was produced, the secondary fragmentation caused many of the diamonds to be ripped in half, have the middle blown out, and other anomalies.

Test Results

Each of the seven tests was analyzed in the same method. This consisted of plotting the data into 25 grain regions, comparing to the baseline Mott Curve, sorting the fragments, weighing diamonds, and finally plotting the diamonds versus the total fragments. Due to space limitations in this report, the reduction procedure will be shown for only two shots, Shots 2 and 3. Results will then be given for all shots.

Shot 2—

When compared with the baseline Mott Curve, some vast differences can be seen in Shot 2 (Figure 11). In the smaller regions (50-250 grains), there are considerably fewer fragments than are predicted for a naturally fragmenting case. Following the same lines, in the larger regions (500-850 grains) there are more fragments than the Mott Curve predicts. This plot shows exactly what was expected. The liner successfully manipulated the case

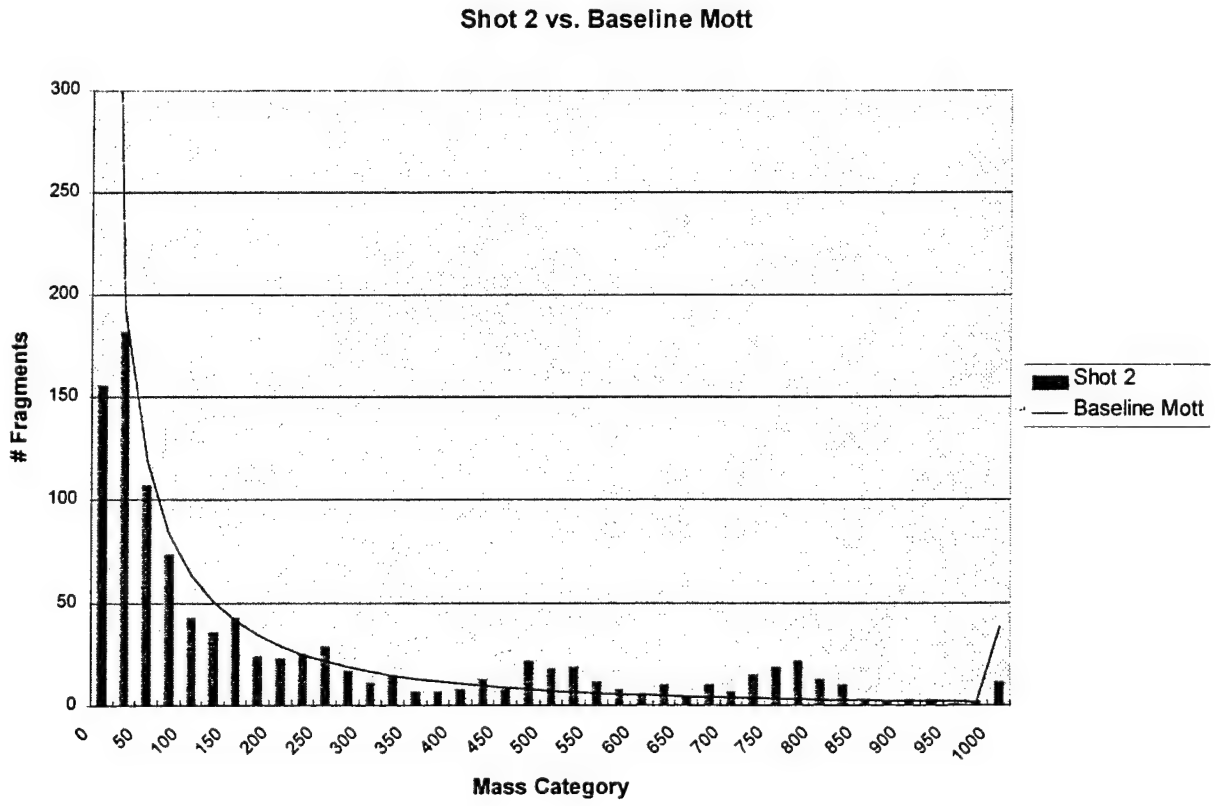

Figure 11: Shot 2 vs. Baseline Mott

fracture to cause many of the smaller fragments to hold together as larger fragments. However, one minor discrepancy exists. The actual peak in the larger regions falls out in the 750-850 grain region, while the predicted diamond size was only 600 grains. This is easily understood, though, when it is realized that the predictions were based solely on the geometry of the liner and the case, not taking into account the "wings." The mass distribution among the diamonds could be quite different considering some had both wings attached, some only one, still others had only the pure diamond shape.

When the diamonds had been separated from the rest of the fragments and weighed, they were plotted against the total fragment distribution (Figure 12). The majority of the diamonds fell out in the desired weight region. This means the fragments that were affected by the liner were of the specified size. This coupled with the fact that 67.87% of the total case mass collected was in the form of diamonds leads to the conclusion that this was a very successful test. The control of the "wings" could lead to a more narrow size band width.

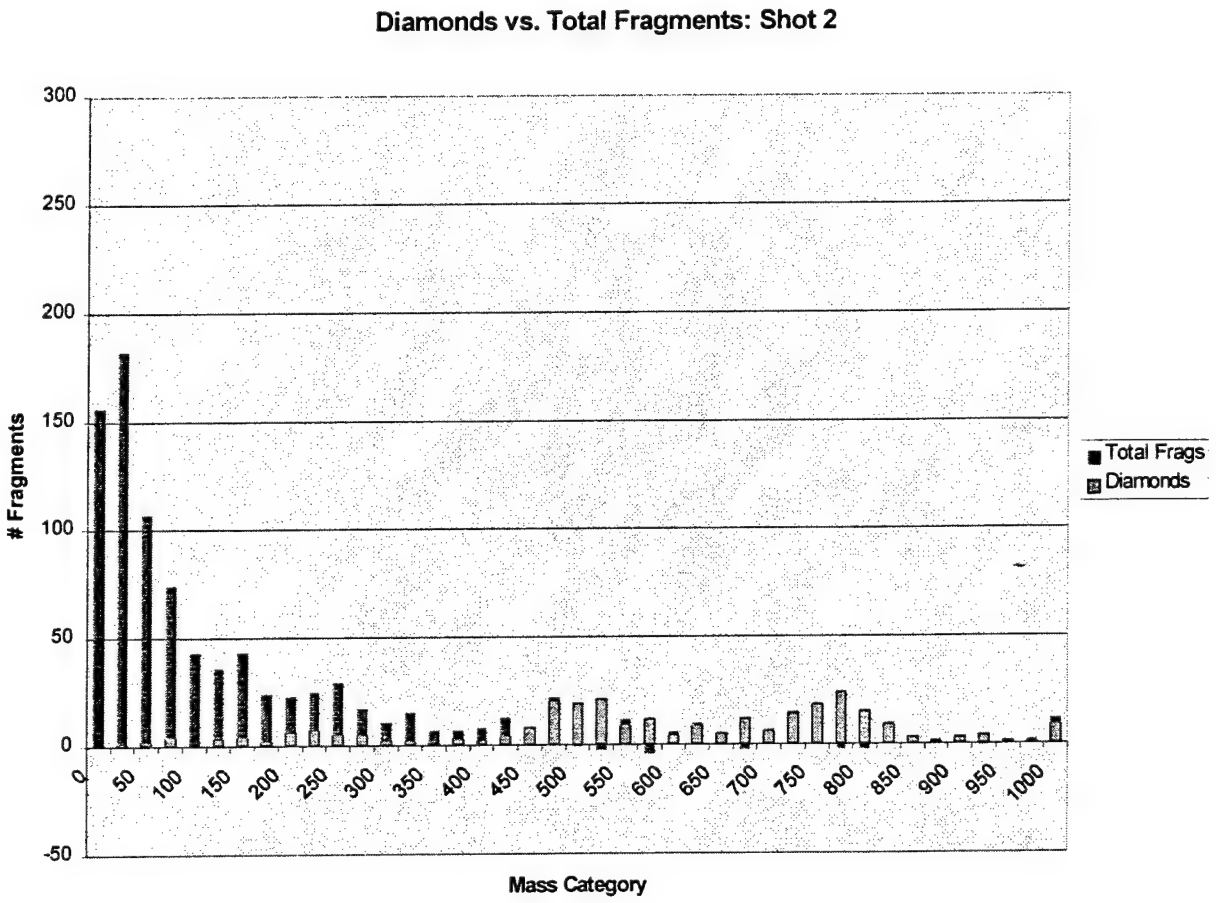

Figure 12: Shot 2 "Diamond" distribution

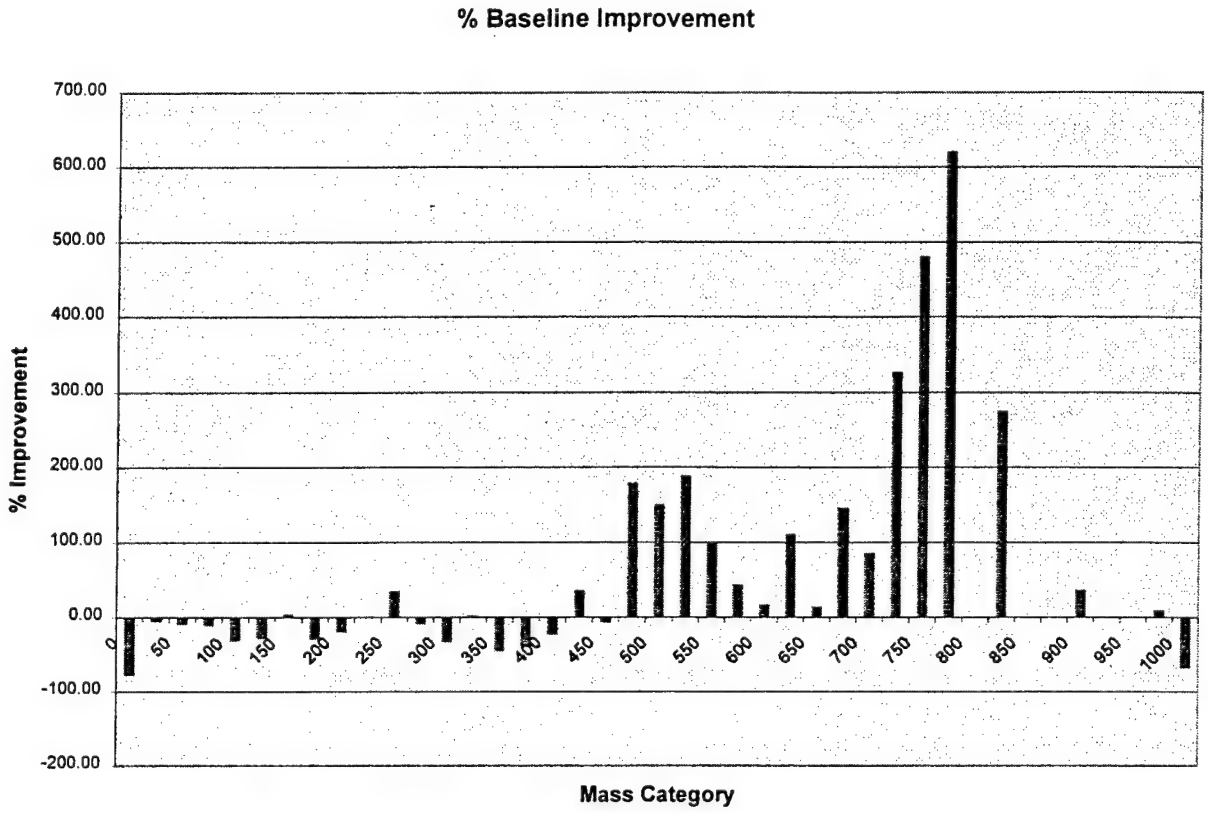

Figure 13: Shot 2 % Improvement over Baseline Mott

The total percent improvement of Shot 2 over the predicted results reconfirms the favorable results (Figure 13). There is a substantial percent improvement over the baseline Mott in the desired ΔM region (over 600%). One important aspect noted from these results is the lack of a localized peak in one category, but rather it gradually builds and drops off. The actual percent improvement is more than just the highest peak of 600% shown, but is the sum of the improvement in the desired ΔM region (17 times the baseline). This graph indicates a desirable negative percent improvement in the small fragment categories. Again, this shows the desired effect that fewer small fragments are being generated. The case fracture was therefore manipulated as predicted.

Shot 3—

The expected results from Shot 3 were just the opposite of those from Shot 2. The specific purpose of this test was to produce fewer larger fragments by cutting them into more smaller fragments. This would show that the "waffle" liner has the capability to go both ways in controlling fragmentation. Not only could it force fragments to remain as larger ones, but also it could reduce fragments into smaller, more numerous ones.

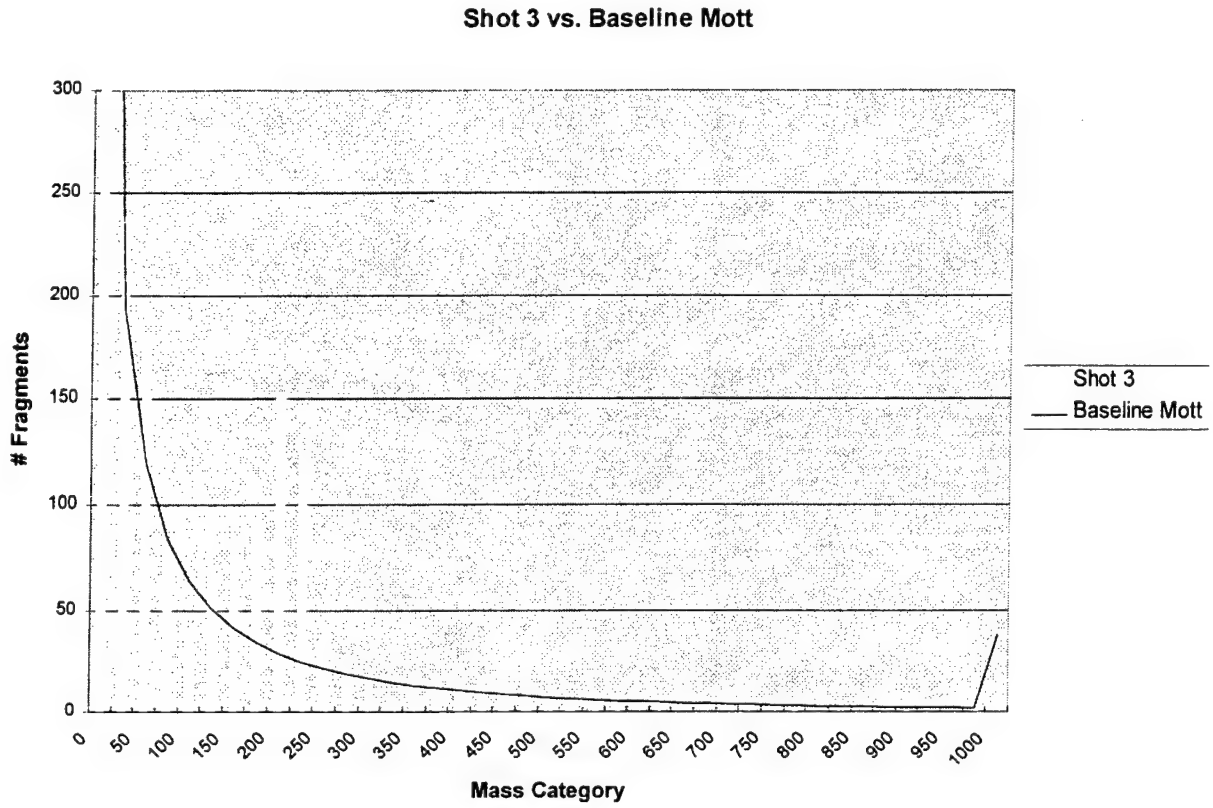

Figure 14: Shot 3 vs. Baseline Mott

When reviewing the resulting data from Shot 3 (Figure 14), it is important to remember that this is the shot predicted to produce 250 grain fragments. This result was well demonstrated. For roughly every mass category greater than 500 grains, there were fewer fragments than would "naturally" have been generated. In the predicted ΔM (250 grains), there was a much larger quantity of fragments than in the baseline.

Furthering the point that the fragments were produced according to the desired pattern is the fact that the "diamond" fragments fell out in the 250 grain region (Figure 15). The "waffle" liner had caused the case to break up along the liner bands. Again, a high percentage of the case mass was collected in the form of diamonds (67.48%). From these results, this test appears to be successful.

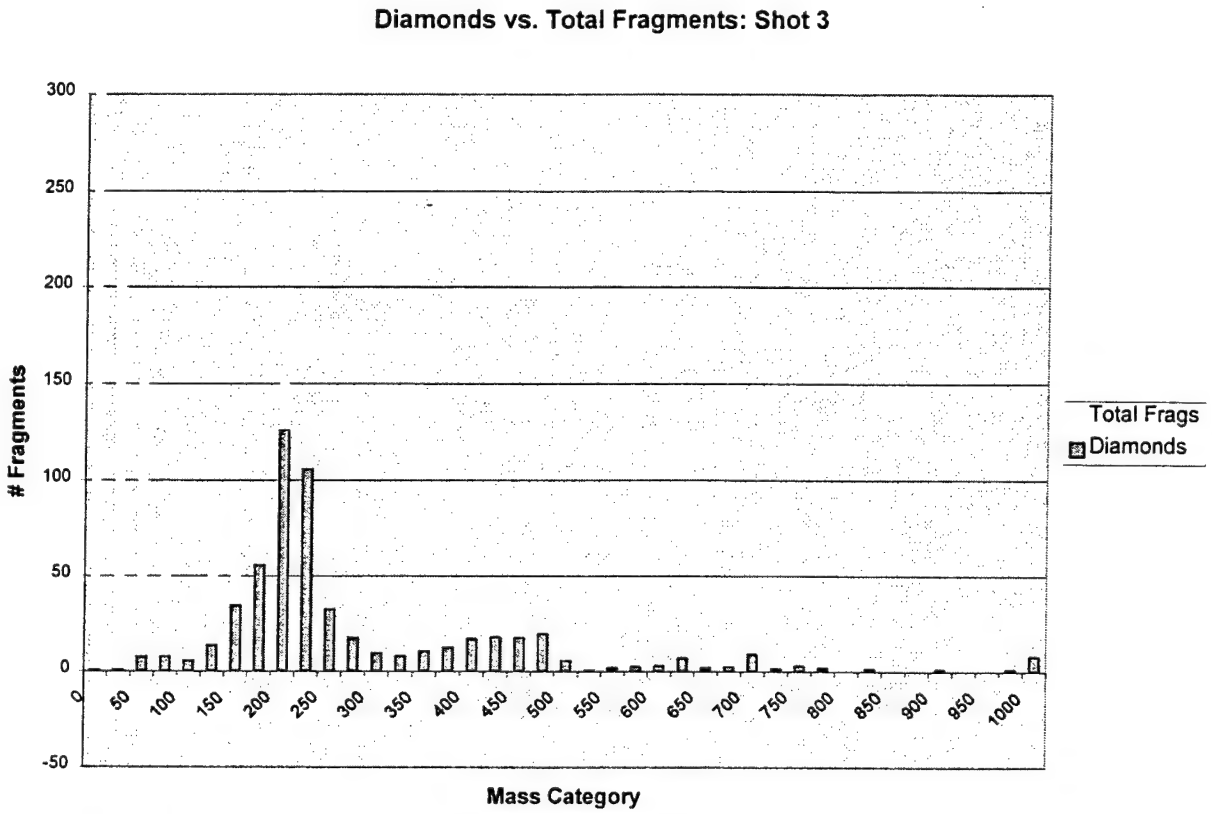

Figure 15: Shot 3 "Diamond" distribution

The results of Shot 3 show some tremendous percent improvement over the baseline (Figure 16). This means some of those smaller fragments are hanging together as larger ones. From the 525-1000 ΔM more negative percent improvements are shown. There is over a 400% improvement in the desired category (250 grains). Again, this is not a sudden spike, but an increase over a broad region. However, many of the large fragments did not completely break up. They contained multiple diamond cuts from the liner, but never completely fragmented. If they could have been forced to fully fragment, there would be a higher improvement in the desired region. Overall, this turned out to be a very successful test design.

entire band width. There were not as many small fragments as would be produced in a "natural" test, leading to the conclusion that the fragmentation had been controlled, though not completely.

Shot 5 also had the liner's diamond pattern in the fragments. The diamonds fell out in a semi-broad range. In actuality, they were confined around the desired region, but again there was no specific jump in the number of fragments or percent improvement in any given ΔM. However, positive results are shown in that there are fewer smaller fragments and more fragments in the desired mass category. Slight adjustments in the liner may produce better results.

The test that was predicted to generate 1200 grain fragments, Shot 6, had both positive and negative results. The desired diamond shape was observed in the fragments, and the diamonds peak at the desired weight category. However, there was much secondary fragmentation within the diamond fragment. Thus, although the diamond was produced, the secondary fragmentation broke the diamonds up in a random fashion. Examples are half-diamonds, diamonds with the middle missing, etc. The size of liner used in this test it beyond the threshold capability of the "waffle" liner.

The last test item, Shot 7, had results similar to those of Shot 1. Although the desired fragment pattern was produced, the diamonds cover the entire ΔM range, with no specific peak. This test would not be deemed a success. It is thus determined that it is more difficult to influence the fragmentation pattern in harder steel.

Conclusion

This test series had a mission to validate the HDPE "waffle" liner's potential to control fragmentation. This goal was accomplished. The "waffle" liner was proven as a valid means of controlling fragmentation of warhead cases. The desired "diamond" shape was produced in all shots. On average, a high percent improvement over the baseline was shown throughout the tests. The mission goals, to design a low cost method to control fragmentation while retaining structural integrity, were also met. Further, the hydrodynamic analysis (computer simulation of case break up) correctly predicted the case fracture. It has been proven to be a very important tool, saving time and money by running a preliminary test on computer rather than actual testing.

Currently, a blast analysis is being processed. Its purpose is to determine pressure, impulse, and fragment velocity equivalencies when compared with a baseline.

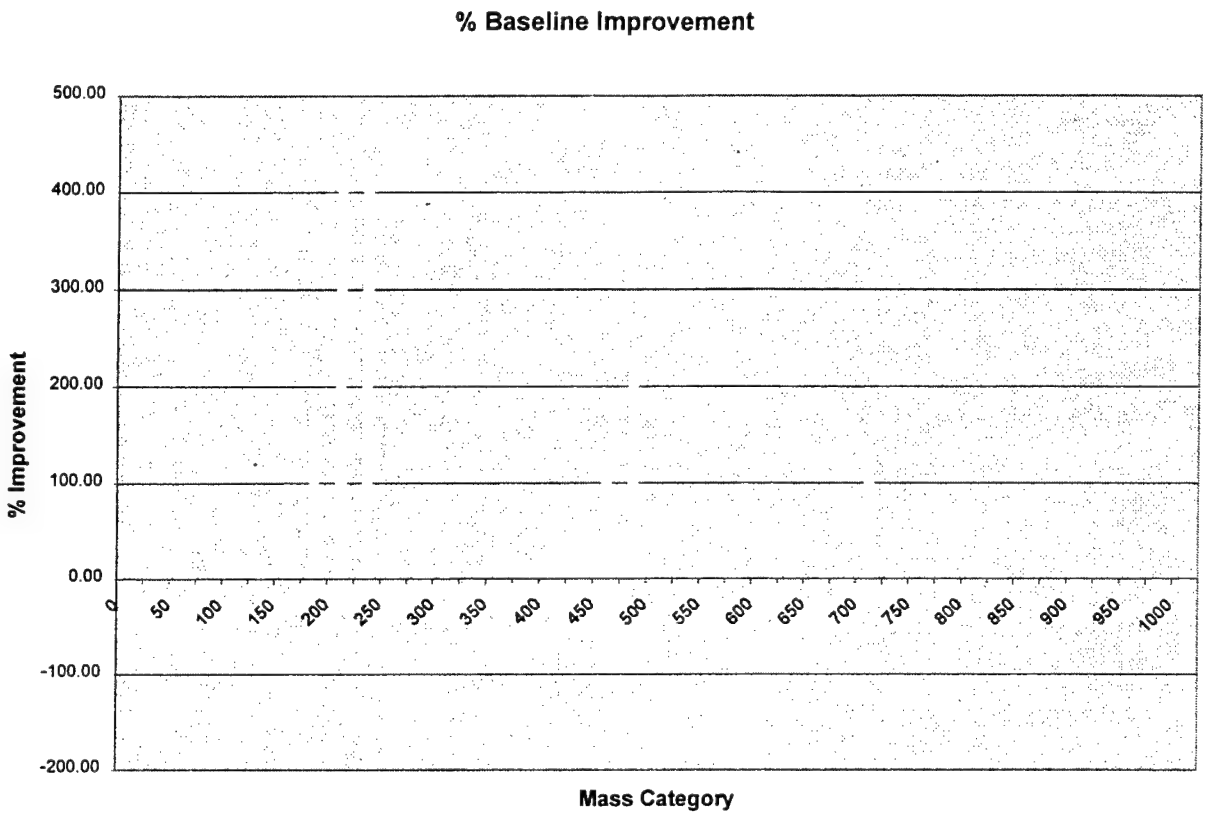

Figure 16: Shot 3 % Improvement over Baseline Mott

Shot 1, 4-7—

Having given the specifics for Shots 2 and 3 for the purpose of demonstrating how conclusions on the data results were arrived at, general results will now be given for the remainder of the tests.

Shot 1 produced the desired fragment pattern. That is, the expected diamond shape was found in the fragments from the test. However, there were multiple sizes and shapes of diamonds. Many were broken in half, had the wings ripped off, etc. This was displayed in the Diamond distribution graph. There was no specific peak where a large number of diamonds fell out. Rather, they were spread over the entire ΔM range. This test was good in that the diamond pattern was seen, however with no specific diamond peak, the case is not being completely manipulated by the liner.

The fragments in Shot 4 also produced the desired diamond pattern in the fragments. Like Shot 1, there was no specific diamond peak. This may be because the diamond shapes in the liner had too extreme linear dimensions. The diamonds were so tall and thin that the pressure wave may not have been affected enough to cause complete control. This test looked better that Shot 1, though, because the diamonds were not spread across the

[1] Johnson, C. and Moseley, J.W. PRELIMINARY WARHEAD TERMINAL BALLISTIC HANDBOOK U.S. Naval Weapons Laboratory, Dahlgren, Virginia. 31 Mar 1964. pp 15-18

[2] Ibid. pp 16-18

[3] Horsey, 1Lt Michael L. Interview, 13 Aug 1998.

[4] PRELIMINARY WARHEAD TERMINAL BALLISTIC HANDBOOK pp 2-9

DEVELOPMENT OF DVAT:
A DIMENSIONALLY VARYING ANALYTICAL TOOL

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And

Wright Laboratory

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Abstract

A plotting program was created using Visual C++. This program, Dimensionally Varying Analytical Tool (DVAT), plots X-Y data in relation to some other variable, such as time. To display the sets of X-Y pairs as changing in relation to a third variable, each set of X-Y pairs is graphed in succession, creating a moving line.

One or two sets of data can be observed at one time, and the user can control the speed of display and other aspects of the plot. Color of the line can be linked either to Y values, as positive and negative, or to X values, with five variable ranges. An output file option is also available, which provides information such as extrema, integrals, and average y value for each set of X-Y pairs. DVAT can also create derivative files, with respect to X or T, that can then be read back in as input files.

DEVELOPMENT OF DVAT:

A DIMENSIONALLY VARYING ANALYTICAL TOOL

Neil N. Harrison

Introduction

Standard XY plotters are very useful and very common. They can be used to plot strain along a projectile or perhaps strain in one element over time. If someone needs to plot strain along a projectile over time, however, they must graph each timestep separately, then look at the graphs one by one. DVAT is an XY plotter that varies over a third variable, making a plot that varies with time, or any other variable, possible. It is done by using time as a third dimension, creating the effect of a line moving as the third variable changes. This type of plotter can be, and is being used for several types of analysis. One run of DVAT can replace hours of making two dimensional graphs and viewing them separately.

Methodology

The first step in creating DVAT was learning Microsoft Visual C++. Even with a general knowledge of the C++ programming language, Visual C++ is a new environment. Standard classes and their interactions must be learned and understood before a program is started. This was accomplished with the help of the Microsoft Visual C++ help files, several books on Visual C++, and discussions with experienced users. Once a general understanding of Visual C++ was present, the project could be started.

Next, a working XY plotter was developed. When a project is started in Visual C++, part of a program is already written. This program included the basics of all windows programs, including menus, a toolbar, a status bar, and the minimize, maximize, and close buttons. The basic features, such as the minimize, maximize, and close buttons, and the new menu command and toolbar option worked, but the rest of the features had to be "wired up".

After the XY plotter was created, the third variable capability was added. This was at first done with data generated within the program. The data consisted of a moving straight line or a changing polynomial function. After a debugging process to eliminate problems such as a line always going back to point (0,0) or the lines not being erased between frames, the data creation part of the program was removed and an input capability was added. It was decided that the input file format would be a time value (time is used throughout this report as a reference to the third variable, since it is the most common one used), followed by a newline character, then the XY pairs for that timestep, each pair on one line separated by one or more whitespace characters (spaces or tabs) and followed by a newline character. The following sample input file would have two timesteps and five XY pairs per timestep.

```
.10000000E+01
.00000000E+00  .00000000E+00
.50000000E+00  .25000000E+00
.10000000E+01  .10000000E+01
.15000000E+01  .22500000E+01
.20000000E+01  .40000000E+01
.20000000E+01
.00000000E+00  .00000000E+00
.50000000E+00  .10000000E+01
.10000000E+01  .40000000E+01
.15000000E+01  .90000000E+01
.20000000E+01  .16000000E+02
```

The number of timesteps in an input file is limited only by the memory of the computer DVAT is being run on. The maximum number of XY pairs per timestep is 1000. Changing the constant definition of MAX_XY_PAIRS at the top of the files CPlotterView.cpp and CPlotterDoc.h can alter this limit.

After the input file capability was added, the program was tested by in-house personnel and additional options were added as required based on user feedback. Just like any other program, no point can be reached at which no improvements can be made, so options were added until the summer research program was over.

Features of DVAT

Through the development process, options were added to DVAT that were not originally considered. The basic run control options were required from the beginning. Play  starts the run, Stop  pauses the run, and Reset  moves it back to the starting frame. Two additional run control options were added later. One  advances one frame, the other  backs up one frame. Another toolbar button brings up the Options Dialog Box  (see appendix 1). This box includes color options, a continuous loop option, a time delay control, and options to change the range, starting frame number, and name of the dynamic variable. Colors varied by either X values or Y values. If they are chosen to depend on Y values (default), then one color can be chosen for positive values, and one color can be chosen for negative values, or both can use the same color. If colors depend of X values, the user can specify up to five ranges with a color for each range. Available colors are red, blue, green, and black.

After an initial file is input, an additional file can be read in by selecting "open second file" in the file menu or using the  button in the toolbar (see appendix 2). Files can be appended to the current file or plotted separately. If appended, the XY pairs of the new file are added after the XY pairs of each timestep of the old file. In this case, the total number of XY pairs per timestep must not be greater than 1000 (see above). Whether appended or opened separately, the second file must have the same number of timesteps as the first. There are scaling options found in the Tools menu that allow the user to automatically scale both files to either the first, the second, or the extrema of both files (largest xmax, smallest xmin, etc.).

Two types of ASCII files can be output from DVAT . The first type is an information file that gives information in column format for each timestep including extrema, the total range of Y values, the average Y value, and two integral values, one counting all area as positive, the other counting area below the Y axis

as negative. A second output file type is a derivative file, which outputs the derivative of Y with respect to either X or the dynamic variable. The derivative file can be read back into DVAT and viewed.

Program Mechanics

Most of the newly developed functions in DVAT are located in the CPlotterView class. Some important variables, however, are located in CPlotterDoc, where the class is defined that contains the XY data. The frame class contains an array of X data, an array of Y data, and a time. All of these values are double precision floats. A pointer named ***set*** is the head of a future array of frame-type objects. Other variables in CPlotterDoc include the extrema and the number of pairs per timestep. There are two variables for each of these values, one for the first file, and one for an optional second file.

CPlotterView also contains some important variables. One of these is ***framenum***, which keeps track of which frame is being displayed. This is accompanied by ***stopnum***, which tells the program where it has paused. Another important variable in CPlotterView is ***finis***, which is a controller flag. When set to 0, the program doesn't do anything. When play is selected, a function sets ***finis*** to 17, then indirectly calls OnDraw() by calling Invalidate(). If ***finis*** is set to 17, OnDraw() calls plotgraph(), which starts the run. Different values of ***finis*** signal different actions. A value of 3 signals reset, a value of 5 signals a frame advance, and a value of 7 signals a frame back up. Single frame operations such as these are accomplished through the function plotframe(). Another variable in this class is ***flag***. This variable keeps track of how many files are opened. It is almost always 0, 1, or 2. A value of –1 for ***flag*** signals an error in the GetFileInfo() function. ***Maxframes***, another important variable in the CPlotterView class, is the number of timesteps in the opened file or files (all files open at the same time must have the same number of timesteps). This is also where variables controlling options such as continuous loop, color selections, and time delay are found. The last addition to the CPlotterView class was the ***zeroaxis*** variable. This is a Boolean value (true or false) which controls whether the Y-axis is plotted along the bottom of the graph or in the middle. This is determined automatically when the file is opened.

When an option is selected, a message is sent to a message-handler function. The message handlers were written to either perform the task or send information to another function to allow that function to perform the task. Most simple tasks were handled within the message-handler function (such as the scaling options). Other tasks, such as starting the run, took as many as three or four functions to perform.

Minor modifications were also made to the CChildFrame class. A few lines of code were added in the PreCreateWindow() function that regulated the size of the plotter window. WINDOW_SIZE can be altered by changing its definition in CPlotterView.cpp, CPlotterDoc.h, and CChildWindow.cpp. WINDOW_SIZE is the size in pixels of the plot window. It is currently set for 600, but on low-resolution monitors, it needs to be smaller. The CCompleteOptions Dialog class was changed to control the slider bar used for time delay.

Results

After the time varying capability was developed, DVAT was tested by two engineers, using it for very different types of data. Their feedback provided ideas for many new options, including the second file capability and auto scaling. They now have final versions and are using them for their work.

Mr. Dave Lambert at the Advanced Warhead Experimental Facility (AWEF) is using DVAT to analyze Split-Hopkinson Pressure Bar tests, used to develop new concrete material models. In these tests, a shockwave is sent down an incident bar, through a specimen, and into a transmitter bar. This wave is partially reflected and partially transmitted at each material boundary, and data are gathered for each region and saved to disk. Mr. Lambert is using DVAT to visualize the shockwave traveling through the bars, and reports that approximately two hours per run is saved because of DVAT.

Mr. Michael E Nixon is using DVAT for material characterization. First, experimental data are gathered by firing a cylinder into an anvil and observing the deformation of the cylinder. Then a finite element code is used to simulate this impact. Material model parameters are changed and DVAT is used to visualize how

they effect the predicted deformation (see appendix 2). It can also be used to tweak the parameter until the deformation given by the prediction code matches the experimental deformation. Again, comments have indicated that DVAT has been extremely useful to this type of research.

Conclusions

DVAT was successfully created with all necessary options. Also, many options were added later based on feedback from testers. DVAT has also already been proven to be very useful in many different situations. It can save hours of time and allow people to visualize things better than conventional plotting methods. DVAT is already in use and it is expected that it will find other uses in the future. Further development may be accomplished by a future HSAP.

Another thing I have gained from the project was an increased knowledge of Visual C++. I entered the summer with a knowledge of C++, but I had not programmed in Visual C++. While writing DVAT, I greatly improved my knowledge and ability as a Visual C++ programmer.

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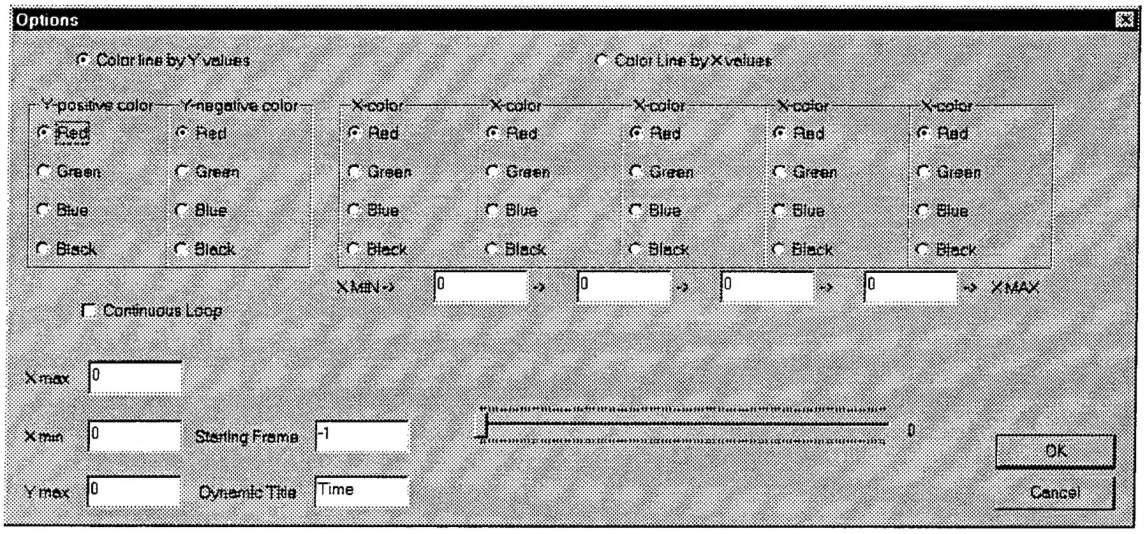
Lambert, Dave. Program testing and input data.

Nixon, Michael E. Program testing and input data.

Appendix 1: Options Dialog Box



Appendix 2: Two plots open - Material Characterization data